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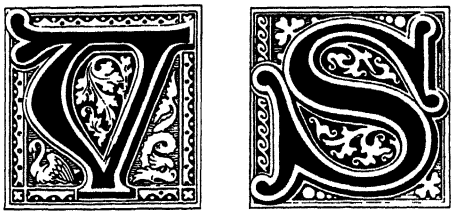


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Cover illustration "The extinct animals model-room, at the Crystal Palace, Sydenham" (*Illustrated London News*, December 1853)

ADVICE TO CONTRIBUTORS

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Richard Yeo

SCIENCE AND INTELLECTUAL AUTHORITY IN MID-NINETEENTH-CENTURY BRITAIN: ROBERT CHAMBERS AND *VESTIGES OF THE NATURAL HISTORY OF CREATION**

ROBERT CHAMBERS' ANONYMOUS WORK, *Vestiges of the Natural History of Creation*, is well known as a best selling statement of evolutionary speculation before Charles Darwin Although mainly known as a publisher, Chambers was an amateur geologist and a voracious reader of scientific and philosophical literature His book, which first appeared in 1844, offered a general theory about the origin and development of the natural world, and was presented as "the first attempt to connect the natural sciences into a history of creation "[1] The nature of Chambers' theory, its relation to Darwin's, and its social and intellectual impact on Victorian society have been studied by social historians and historians of science [2] While drawing upon this scholarship, the present article attempts to consider the controversy provoked by Chambers' work in terms of the questions it raised about the image of science and the authority of the scientific community

The *Vestiges*, as it came to be called, met with a deluge of criticism. The charges brought against the author were serious ones — lack of practical research, second-hand knowledge, and disregard of proper scientific methods. The extent of this attack led Chambers to

* I would like to thank the following people for their useful comments on drafts of this article Charles S Blinderman, Ludmilla Jordanova, David Oldroyd, and Barry Smith A version of the article was read at the Wellcome Institute for the History of Medicine at Oxford, and I thank the participants for their discussion Research was financially supported by the School of Humanities, Griffith University

[1] [Robert Chambers], *Vestiges of the Natural History of Creation* (London J Churchill, 1844), p 338 The authorship was revealed in the 12th edition of 1884, published after Chambers' death

[2] The standard work is Milton Millhauser, *Just before Darwin Robert Chambers and Vestiges* (Middletown, Connecticut Wesleyan, 1959) For a more recent work which analyzes the differences between the projects of Chambers and Darwin, see M J S Hodge, "The Universal Gestation of Nature Chambers' *Vestiges* and *Explanations*," *Journal of the History of Biology*, 5 (1972), 127-151

publish a sequel in which he claimed that his argument had been misunderstood,[3] and successive editions of the original work were also revised to take account of objections and to incorporate recent scientific material This running battle with reviewers culminated with the tenth edition of 1853, which included an extensive appendix in which Chambers replied to criticism by showing that his authorities were also the authorities of contemporary science He was able to quote experts in support of different parts of his book and cited passages from the works of Adam Sedgwick which suggested that the famous geologist once countenanced the general position he now condemned [4] Chambers was also able to exploit tensions connected with the growing specialist divisions within science by indicating, for example, that Sedgwick was "neither an anatomist or naturalist" and could not be accepted as an authority in these areas (Chambers, *Vestiges*, 10th ed., p xlix) He objected to the fact that the work of another critic, Hugh Miller — the Scottish writer and amateur geologist — had been "officially patronized and applauded" while his own had been castigated as "anti-scientific." Marshalling the kind of rhetoric which had been used against him, and again referring to the views of a well-known man of science, Chambers remarked that "twenty chapters from a mere working geologist and *litterateur* like Mr Miller could not stand against" the authority of Professor Louis Agassiz (Chambers, *Vestiges*, 10th ed., p xxxix) He suggested that the public should be "on their guard" against the duplicity of men of science and should decide which authorities to accept

The way in which Chambers was able both to challenge and invoke authorities from the scientific community, to exploit tensions between them, and to appeal directly to public judgement, highlights the issues at stake in the controversy surrounding *Vestiges*. But before investigating this question of authority in science, it is important to place it in the context of a wider contemporary concern about the exercise of intellectual authority in a period of expanding knowledge and democratic reform.

I

In his *Democracy in America*, Alexis de Tocqueville suggested that the egalitarian ethos led to a rejection of the authority of learned

[3] [Robert Chambers], *Explanations a Sequel to Vestiges of the Natural History of Creation by the author of that Work*, 2d ed (London J Churchill, 1846)

[4] [Robert Chambers], *Vestiges of the Natural History of Creation, with extensive additions and emendations* (London J Churchill, 1853), pp l-li, lviii

elites [5] This analysis found a receptive audience in Britain and was in fact anticipated by J S. Mill who regarded the early decades of the century as an interregnum: traditional doctrinal authorities were in decline but no new intellectual authorities had appeared [6] Instead, with the rise of the industrial middle classes and the emergence of public opinion as a political force, there was a danger that the criterion of popularity would come to decide the acceptability, and even the truth, of ideas [7] He noticed a flowering of quackery and ephemeral literature all manipulated by the new "arts for attracting public attention."[8] With the growth of a mass market for information there was a multiplication of popular and elementary texts conveying knowledge in simple, accessible forms Consequently, "the grand achievement of the present age" was the "diffusion of superficial knowledge" (Mill, "Spirit," p 30) In itself, Mill did not view this as regrettable, but in a period characterized by the dogmatism of common sense, it created an indifference to theory and expertise Against this attitude he urged the need for a clear distinction between common sense and informed judgement, between superficial and profound knowledge He argued that the public would have to be convinced that the scope of individual judgement was limited, and that on some subjects it was necessary to "fall back on the authority of still more cultivated minds" (Mill, "Spirit," p. 44) This issue assumed a special urgency from the time of the First Reform Bill, when questions of intellectual and political authority were explicitly connected

During the first half of the nineteenth century, the increasing specialization of knowledge made the locus of intellectual authority more difficult to define. Writing in 1849, in his *Essay on the Influence of Authority in Matters of Opinion*, George Cornewall Lewis declared that "there is no one body of persons who are competent to judge on all subjects, and who are qualified to guide all sorts of opinions; that there is no one intellectual aristocracy, separated from the rest of the community, and predominating over them indiscriminately Every subject, in turn, has its own peculiar set of judges "[9] With wider dis-

[5] Alexis de Tocqueville, *Democracy in America*, 2 vols (New York A Knopf, 1953), II, 3-12

[6] John Stuart Mill, "The Spirit of the Age' in J B Schneewind, ed , *Mill's Essays on Literature and Society* (New York Macmillan, 1965), pp 33-38 See his favourable review of de Tocqueville, "Democracy in America," *Edinburgh Review* 72 (1840), 1-47

[7] See William Mackinnon, *On the Rise, Progress and Present State of Public Opinion* (London Saunders and Otley, 1828) for an early analysis

[8] John Stuart Mill, "Civilization Signs of the Times,' *Westminster Review*, 27 (1836), 15

[9] George Cornewall Lewis, *An Essay on the Influence of Authority in Matters of Opinion* (London J Parker, 1849), p 167 This is a systematic treatment of the problem posed for individual judgement by the specialization of knowledge On a related theme, see Ben Knights, *The Idea of the Clerisy in the Nineteenth Century* (Cambridge Cambridge University Press, 1978)

semination of information through popular texts, the problem facing intellectual elites was one of ensuring that distinctions between expertise and common sense were maintained As early as 1833, one writer stressed the need for what he called the "government of knowledge "[10]

A large part of this contemporary discussion dealt with social and political subjects in which the disposition to trust common-sense opinions was strongest In the 1830s, for example, exponents of political economy such as Nassau Senior and Richard Whately contended that questions raised by this discipline required the unlearning of common-sense attitudes and the adoption of systematic scientific methods [11] References were often made to the lack of certainty in the moral and social sciences in comparison with the strong consensus over fundamental principles in the natural sciences But the question of authority was also relevant to natural science and it concerned the leaders of the scientific community Lewis suggested one reason for this when he noted that the increasing popularity of science had encouraged the emergence of "mock sciences" such as mesmerism, homeopathy, and phrenology (Lewis, pp 51-52)· "No species of imposture is so captivating, so well-suited to the present time, and consequently so likely to meet with temporary success, as that which assumes the garb, and mimics the phraseology, of science" (Lewis, p 55) Given this situation it was imperative that the scientific community assert its authority in public in order to distinguish between genuine and pseudo-science.[12] In order to appreciate the context of this problem, it is necessary to consider the position of science in early Victorian society

Several recent authors have referred to the close relationship between "natural knowledge and the general culture" of the early Victorian period [13] This situation is contrasted with the divorce between science and other forms of knowledge which occurred in the last half of

[10] Edward Bulwer Lytton, *England and the English*, 2 vols (London R Bentley, 1833), II, 122

[11] Richard Whately, *Introductory Lecture on Political Economy*, 3d ed (London B Fellowes, 1847), pp 55-64, 208, 215-17, Nassau Senior, *Introductory Lecture on Political Economy* (London J Mawman, 1827), pp 1-2, 24-28 On the emergence of political economy as a discipline, see Maxine Berg, *The Machinery Question and the Making of Political Economy 1815-1848* (Cambridge Cambridge University Press, 1980)

[12] On this problem of demarcation, see Roy Wallis, ed , *On the Margins of Science The Social Construction of Rejected Knowledge* (Sociological Review Monograph, no 27, University of Keele, 1979) On phrenology, see Roger Cooter, "Deploying 'Pseudoscience' Then and Now," in M P Hanen, M J Osler and R G Weyant, eds , *Science, Pseudo-Science and Society* (West Waterloo, Ontario Wilfrid Laurier University Press, 1980), pp 237-272

[13] Arnold Thackray and Steven Shapin, ' Prosopography as a Research Tool in the History of Science, *History of Science*, 12 (1974), 11 See also, Robert Young, "Natural Theology, Victorian Periodicals and the Fragmentation of a Common Context" in C Chant and J Fauvel, eds , *Darwin to*

the century, especially after 1870 when both scientific and non-scientific disciplines became more specialized and separated, by professional accreditation, from the generally educated public Evidence of the integration of science with culture before this fragmentation can be found in the Victorian periodicals [14] The major quarterlies and magazines treated science as part of a broad intellectual framework which included theology, literature, philosophy, and political economy Reviewers often moved freely across these disciplines, and science was presented in a manner which assumed an informed readership The great debates on geology, evolution, and their religious implications were conducted in these periodicals, and this meant that the meaning and status of science were matters of public discussion

But while these debates reflected the interest in science amongst general readers, they also indicated the uncertain social position of science in early nineteenth-century Britain Men of science were not differentiated from other educated groups by formal training, and the status of science was not secured by an institutionalized career structure such as that which characterized the legal, medical, and clerical professions [15] This situation supported a general discussion of science but it also meant that men of science were compelled to defend the claims of science in a public forum against powerful opponents such as the clergy

This close relationship between science and general cultural debate, together with the insecure status of the scientific community,[16] made the authority of science a significant issue Scientists had to establish the domain of natural knowledge as their own, and monitor the boundaries between science and religion But they also had to make distinctions between different kinds of scientific knowledge — general and specialist, empirical and theoretical, superficial and profound —

Einstein Historical Studies on Science and Belief (New York Longmans, 1980), pp 69-107, Susan F Cannon, *Science in Culture The Early Victorian Period* (New York Science History Publications, 1978), chaps 1 and 9 Young refers to the place of science in a common intellectual context, Cannon to its position within a Victorian "Truth-Complex "

[14] For a useful general essay, see Walter E Houghton, "Periodical Literature and the Articulate Classes" in J Shattock and M Wolff, eds , *The Victorian Periodical Press Samplings and Soundings* (Leicester Leicester University Press, 1982), pp 3-82 Houghton s *Wellesley Index to Victorian Periodicals*, 3 vols (Toronto University of Toronto Press, 1966-1976) has been used to identify authorship of the reviews referred to below

[15] The contrast with the position of science in France is instructive From the time of Napoleon, scientific institutions were financed by the state, and scientists were ' professional" well before their counterparts in Britain For an early notice of this, see Charles Babbage, *Reflections on the Decline of Science in England* (London Fellowes, 1830), pp 3-30, also Maurice Crosland, "The Development of a Professional Career in Science in France,' in his edition of *The Emergence of Science in Europe* (London Macmillan, 1975), pp 140-141, 154-155

[16] This is a problematic term in the context of early nineteenth-century Britain See Susan Cannon, chaps 5, 6 The debate over *Vestiges* reveals some of the difficulties surrounding terms such as "professional,' "amateur," "expert," and "popular science "

which were produced by popularization and specialization The following sections of this article investigate a prominent example of a public debate which involved these questions of demarcation

II

One contemporary reviewer of *Vestiges* began by observing that "it has been warmly received by the public, and fiercely attacked by the physical philosophers "[17] The explicit target of this hostile reaction was Chambers' theory of Progressive Development which involved the concept of the transmutation of species and its application to man In spite of his criticism of Jean Baptiste Lamarck, Chambers' work revived the prospect of a connection between science and materialism, an association which had political implications in the aftermath of the French Revolution In Britain during this period, the spectre of French materialism and its radical connotations often shaped responses to scientific and philosophical thought. In the year of Peterloo, for example, the lectures of William Lawrence, which advocated a naturalistic approach to the study of the mind, were widely attacked not only for their theological consequences but because of their alleged affinity with French physiological theories, such as those of Xavier Bichat [18] Lawrence was accused of both blasphemy and sedition, and while he proclaimed the internationalism of science, two major periodicals reminded him of the dangers of importing French ideas [19]

Since 1819, although there was a continuing debate about the relationships between science and religion, the question of the materialist tendencies of science was not the central issue Rather, most public discussion focussed on the new discipline of geology and its implications for Biblical literalism; and by the 1830s, various degrees of compromise had been reached [20] The public relations of the British Association were designed to link science with a bland natural theology which stressed the moral and social benefits of natural knowledge [21] In

[17] Francis Newman, "Explanations A sequel to the Vestiges of the Natural History of Creation," *Prospective Review*, 2 (1846), 33

[18] See Peter G Mudford, "Lawrence's Natural History of Man (1819)," *Journal of the History of Ideas*, 29 (1968), 430-436, June Goodfield-Toulmin, "Some Aspects of English Physiology 1780-1840," *Journal of the History of Biology*, 2 (1969), 307-320

[19] William Lawrence, *Lectures on Physiology, Zoology, and the Natural History of Man* (London J Callow, 1819), p 15, *Quarterly Review*, 22 (1819), 33, *British Critic*, 12 (1819), 95

[20] R M Young, "The Impact of Darwin on Conventional Thought," in Anthony Symondson, ed , *The Victorian Crisis of Faith* (London Society for Promoting Christian Knowledge, 1970), pp 13-35

[21] Jack Morrell and Arnold Thackray, *Gentlemen of Science Early Years of the British Association for the Advancement of Science* (Oxford Clarendon Press, 1981), pp. 224-229

opening his review of *Vestiges*, David Brewster remarked that "we did not expect that this holy alliance would be disturbed either by the philosopher or the divine "[22] But by associating science with controversial materialist ideas in a work of popular circulation, Chambers threatened the rationale of this strategy and the harmony of science and religion it represented In order to restore this alliance, and to preserve the religious and social respectability of science, it was crucial to show not only that the theories in the book were false and dangerous, but that the work itself could not be classified as "scientific "

It is possible to interpret the responses of leading scientists to Chambers' book as indicating a concern about the maintenance of this boundary between true and false science. Furthermore, it could be suggested that *Vestiges* appeared threatening because, in some respects, it was a difficult borderline case For example, when the religious implications of the work were discussed, it was often noted that its natural theology, drawing on the evidence of general laws, was very close to that of leading men of science such as William Whewell, Adam Sedgwick, Baden Powell, John Herschel, and Charles Babbage [23] Secondly, on the substantive question of its scientific content, even some of the critical reviewers remarked on the similarity between its doctrines and those of current European (if not British) science One writer compared it with Alexander von Humboldt's *Kosmos*, thereby awarding it some respectability by association [24]

In spite of its obvious flaws, *Vestiges* could not be easily dismissed as "pseudo-scientific" because it displayed too many positive links with mainstream science The *Athenaeum* attempted to associate it with alchemy, astrology, mesmerism, phrenology, and "other kindred humbugs," alleging that like them, it masqueraded under "the form of true sciences "[25] But this equation was not effective because although mesmerism and phrenology were popular, philosophically controversial doctrines which claimed scientific status, they did not evince the dependence upon orthodox science which characterized

[22] [David Brewster], "Vestiges of the Natural History of Creation," *North British Review*, 3 (1845), 471

[23] [W H Smith], "Vestiges of the Natural History of Creation, *Blackwood's Magazine*, 57 (1845), 449-451, "Natural History of Creation,' *Westminster Review*, 48 (1847-48), 132-134 The additional problem here was that natural theology was a divided subject and, by linking it with evolutionary doctrine, Chambers exposed its weaknesses On varieties of natural theology, see John H Brooke, "Natural theology and the Plurality of Worlds Observations on the Brewster-Whewell debate," *Annals of Science*, 34 (1977), 221-286 and Richard Yeo, "William Whewell, Natural Theology and the Philosophy of Science in Mid-Nineteenth-Century Britain," *Annals of Science*, 36 (1979), 495, 506-509

[24] [J Crosse], "The Vestiges," *Westminster Review*, 44 (1845), 195, 198, Newman, pp 34-36

[25] "Vestiges," *Athenaeum*, no 897 (4 January 1845), 11

Chambers' work, on the contrary, they often adopted a negative attitude towards scientific authorities The author of *Vestiges*, however, employed evidence from recognized sciences, together with material from more dubious sources, in the service of a speculative generalization Indeed, it was this synthetic feature of the book which made it difficult to dismiss *in toto* David Brewster, for example, observed that it covered so many areas that individuals would always find something in it with which they could agree (Brewster, pp 484-485) Writing to the anonymous author, Richard Owen, the leading comparative anatomist, said that "there are a few mistakes where you treat of my own department of science, easily rectified in your second edition."[26] Owen also remarked upon the "summary of the evidences from all the Natural Sciences bearing upon the origin of all Nature, by one who is evidently familiar with the principles of so extensive a range of human knowledge" (Owen, I, 249) Similarly, Darwin told Joseph Hooker that he had been "delighted with *Vestiges* for the multiplicity of parts he brings together though I do [not] agree with his conclusions at all "[27] Even a critical reviewer conceded that the author had "produced a book which may in some manner serve as an outline to the vast range of the natural sciences."[28]

Thus, although particular sections of the book could be shown to be inaccurate or misguided, it was difficult to represent the entire work as unscientific, because it deployed a large amount of recognized scientific thinking and data. The dilemma was exacerbated by Chambers' ability to benefit from criticism: in later editions he altered those sections which gave most offence without retreating from the central thesis. Having seen the fourth edition of 1845, James Forbes told Whewell that the author "has shown himself a very apt scholar, and has improved his knowledge and his argument so much since his first edition that his deformities no longer appear so disgusting "[29] In this way, Chambers continued, with some success, to implicate science, or sections of science, in his theory This process was assisted by the fact that the work dealt with complex subjects in the organic

[26] Quoted in Richard Owen, *The Life of Richard Owen by his grandson*, 2 vols (London Murray, 1894), I, 251 For the question of Owen's attitude to Chambers' theory, see J H Brooke, "Richard Owen, William Whewell, and the Vestiges," *British Journal for the History of Science*, 10 (1977), 132-145

[27] Quoted in Frank Egerton, "Refutation and Conjecture Darwin's response to Sedgwick's Attack on Chambers," *Studies in History and Philosophy of Science*, 1 (1970), 178 See also p 182 for Alfred Wallace's favourable reaction

[28] "Explanations," *Athenaeum*, no 946 (18 December 1845), 1191

[29] James D Forbes to Whewell, 8 January 1846 in J C Sharp, *Life and Letters of James David Forbes* (London Macmillan, 1873), p 178

sciences about which there was no firm consensus As one reviewer observed, "a false theory in natural philosophy is so much more easily corrected than one in physiology."[30] After the tenth edition of *Vestiges* had appeared, the young T. H. Huxley was sure that "in the popular mind the foolish fantasies of the 'Vestiges' are confounded with science, to the incalculable diminution of that reverence in which true philosophy should be held "[31] From this perspective it is possible to suggest that the massive critical effort expended on Chambers' book reflects not only the need to debunk its evolutionary theory and its materialism, but the need to clarify the meaning of science and scientific practice

III

The popularity of the book — it reached a sixth edition by 1847 and sold 20,000 copies by 1860 — made this problem of demarcation at once more urgent and more difficult Indeed, there is evidence that leading men of science regarded it as a case calling for delicate public relations. The correspondence of Whewell, Owen, and Forbes reveals an explicit discussion of strategies for dealing with *Vestiges*. As J H. Brooke has shown, Whewell and Owen believed that it would be best not to reply directly since this would only give the book "an importance calculated to add greatly to its mischief."[32] Owen thought that it would be difficult to refute *Vestiges*, for the sake of those who could not already see its errors, without writing an essay which would inflate its importance Furthermore, it is clear that these correspondents agreed that Sedgwick's eighty-five-page onslaught in the *Edinburgh Review* was ill-advised.[33] Whewell believed that *Vestiges* posed serious tactical problems because it offered bold answers to questions on which "men of real science" showed necessary restraint.[34] He later explained to Sedgwick that "the great difficulty in satisfying the mind of general

[30] "Vestiges of the Natural History of Creation, *British Quarterly Review*, 1 (1845), 490

[31] Thomas Henry Huxley, "Vestiges of the Natural History of Creation, ' *British and Foreign Medico-chirurgical Review*, 13 (1854), 439

[32] Owen to Whewell, 14 February 1844, quoted in Brooke, p 138

[33] Forbes to Whewell, 8 January 1846, Trinity College, Cambridge, Whewell Papers, Add Mss a 204[70]

[34] William Whewell, *Indications of the Creator*, 2d ed (London J Parker, 1846), p 21 Whewell told his friend Richard Jones, the political economist, that no ' really philosophical" work could have had the success of *Vestiges* Whewell to Jones, 18 July 1845, in Isaac Todhunter, *William Whewell D D , Master of Trinity College, Cambridge An Account of His Writings, with Selections from his Literary and Scientific Correspondence*, 2 vols (London Macmillan, 1876), II, 326-327

readers on such subjects is that you have to oppose to attractive positive generalizations nothing but negations and doubts "[35] Sedgwick, however, did not take this hint, and the fifth edition of his *Discourse on the Studies of the University of Cambridge* (1850) carried a monstrous preface which again did battle with the celebrated *Vestiges*

These strategic considerations were posited upon inferences about the level of scientific understanding among the reading public The danger of Chambers' book was said to lie in its appeal to those who were ill-informed on matters of science and logic, and by way of self-confirmation it was argued that the great popularity of the work proved the unscientific character of the public [36] Reviewing the tenth edition of *Vestiges* in 1854, Huxley was depressed by the fact that a book of such transparent nonsense had not "sunk into its proper limbo " This testified, in his view, to the increasing "ignorance of the public mind as to the methods of science and the criterion of truth" (Huxley, p 425) Addressing the readers of a professional medical journal, Huxley revealed a deep pessimism about public conceptions of science. He regarded the level of scientific understanding in *Vestiges* as that derived from the superficial information of "Chambers's [*sic*] Journal" or the "Penny Magazine" and compared its popularity with that of table-turning. This equation of spiritualism and "the science of a Mechanics' Institute" (Huxley, pp. 438-439) indicates a certain desperation about the problem of popularization, a matter which the phenomenon of *Vestiges* had highlighted.

In his book, *Keywords*, Raymond Williams has remarked that the notion of "popularization" still had favourable connotations during the nineteenth century.[37] This is largely true in the case of scientific knowledge, in that leaders of the scientific community believed that their interests would be served by the dissemination of scientific ideas and attitudes throughout society [38] But some qualification is necessary, because not all scientists were sanguine about the benefits of popularization Some of the major figures in the British Association for the Advancement of Science, for example, did not share the enthusiasm of utilitarian reformers such as Henry Brougham At the fourth

[35] Whewell to Sedgwick, [] September 1849, Trinity College, Cambridge, 0 15 48[69]

[36] Whewell said that the book "has its hold on its readers by *their* want of the apprehension of the difference of the nature of truth and falsehood in science and philosophy" (Whewell to F Myers, 16 March 1845, in Janet M Douglas, *The Life and Selections from the Correspondence of William Whewell D D* [London Kegan Paul, 1882], pp 317-318)

[37] Raymond Williams, *Keywords A Vocabulary of Culture and Society* (London Fontana, 1976), p 199

[38] For a section of those views, see Charles Gillispie, *Genesis and Geology* (New York Harper and Row, 1959), chap 7

meeting of the Association in 1834, James Forbes warned that the diffusion of science might not be compatible with its advancement, and this theme was echoed by other important scientific writers such as William Swainson and Augustus De Morgan [39] These anxieties were aggravated by the fact that much popular science appeared to convey an empirical and utilitarian image of science at the expense of its theoretical dimension [40] There was a recognition that good popular works of science were necessary, but most leading scientists did not write at the level demanded for the widest audience For reviewers, this was the lesson of *Vestiges*· "[I]f men competent to the task disdain to popularize science, the task will be attempted by men who are incompetent, popularized it will be" (Crosse, p 153).

The task of enlisting leading scientists to write popular books was not new In 1828, for example, Dionysious Lardner, the editor of the *Cabinet Cyclopaedia*, confided to Herschel that "my chief difficulty in Science is to find profound men who like yourself are able and willing to write a popular work "[41] Herschel wrote his famous *Preliminary Discourse on the Study of Natural Philosophy*, as well as a volume on astronomy, for Lardner's series But although his efforts were loudly praised, there was some disquiet about the tension between the popularization of science and its advancement One commentator doubted the value of employing the best scientists in the composition of popular texts, arguing that the progress of science would be better served if men such as Herschel concentrated on abstract research.[42]

By the 1840s, however, the problem of popularization was more complex than a question of authorship. The larger readership and the diversity of publications produced a more heterogenous audience for science, and the expansion of specialized knowledge exacerbated the difficulties of writing popular books It was suggested that previous examples, such as the works of Mary Somerville which reached educated middle-class readers, were not appropriate those might instruct serious students but they were useless to the general public The *Westminster Review* diagnosed a need for broad surveys of science

[39] James D Forbes, *British Association Reports* (London Murray, 1835), pp xii, xv, William Swainson, *Preliminary Discourse on the Study of Natural Philosophy* (London Longman, 1834), pp 426-427, Augustus De Morgan, "English Science,' *British and Foreign Review*, 1 (1835), 157

[40] [John Herschel], "Whewell on the Inductive Sciences," *Quarterly Review*, 68 (1841), 177-178, 185, [F Whitwell], "Popular Science," *Quarterly Review*, 84 (1848-49), 322, 340-341, [A J Joyce], "The Progress of Mechanical Invention, ' *Edinburgh Review*, 39 (1849), 54

[41] D Lardner to Herschel, 28 July 1828, Library of the Royal Society, London, Herschel Papers, vol 11, no 108

[42] [T Galloway], "Sir John Herschel's Astronomy,' *Edinburgh Review*, 58 (1833-34), 165

rather than elementary treatises on specific disciplines What was needed was "something like a reasonable interpretation of the present state of science — something intelligible to at least the mass of thinking unscientific men" (Crosse, p 153).[43]

To the great annoyance of leading scientists, Chambers' *Vestiges* apparently fitted this description The fact that it met with popular success reinforced anxieties about the effects of popularization which had begun to surface in the early years of the British Association During the 1840s, this disenchantment widened as various commentators drew attention to the public misconceptions about science, its theories, methods and functions [44] These observations were made in contexts ranging from discussions of the role of scientific theory in technology to condemnations of mesmerism and spiritualism Augustus De Morgan, for example, felt it necessary to examine several anti-Newtonian and astrological works in the *Dublin Review* of 1845, explaining that "it is desirable that, from time to time, the public should be guarded against the real evil consequences of ignorant speculation "[45] The manner in which Chambers gave roughly equal status to geological and phrenological theory in his first edition could only have confirmed these fears about the promiscuous nature of popular notions of science Against this background, the success of *Vestiges* demanded that the scientific community assert its authority in order to clarify what was to count as "scientific "

IV

As the copies of *Vestiges* continued to flow from the press, the need for a strong scientific reply became evident Whewell's *Indications of the Creator* was published early in 1845 but this was not seen as a scientific answer — Whewell himself regarded it as a collection of theological extracts from his earlier works Thus, before Sedgwick's review appeared in July, Roderick Murchison wrote to Owen saying that "a real *man of armour* is required, and if you would undertake the concern you would do infinite service to *true* science and sincerely oblige your friends."[46] Murchison anticipated the difficulties con-

[43] There was some comment on the lack of suitable general surveys of science Whewell's works were too sophisticated and Somerville's dealt only with the physical sciences, Herschel s *Discourse* was largely about method In fact, most popular treatments of science dealt with particular disciplines

[44] See for example, Science in 1847," *Athenaeum* (12 January 1848), 60

[45] Augustus De Morgan, "Speculators and Speculations, *Dublin Review*, 19 (1845), 100

[46] Roderick Murchison to Owen, 2 April 1845 in Owen, *Life*, I, 254

fronting a successful scientific rebuttal when he added that, "to be done at all it must be done by a master hand," (Murchison, p. 254) In order to appreciate those difficulties, it is necessary to look at the structure of *Vestiges*

Chambers attempted to explain the origin and development of the natural world by reference to general laws of nature. For the purposes of this argument, he drew upon several areas of scientific evidence and theory The book began with the notion of cosmical evolution by natural law, such as that suggested by the nebular hypothesis of contemporary astronomy The second, and largest section, dealt with the case for a progressive development of plants and animals (including humans) from simple to complex forms by means of transmutation Here Chambers marshalled evidence from the fossil record, comparative anatomy and embryology, ethnology, and phrenology [47] Finally, in an attempt to document the possibility of transmutation from inorganic to organic forms, he offered cases of spontaneous generation obtained by experiments in electro-vitalism (Chambers, *Vestiges*, pp. 165-190) This meant — as contemporaries observed — that the book contained a confusing ensemble of material ranging from accepted scientific data and hypothesis to speculative theory and marginal doctrine

All these facets of the book came under attack, but they raised different problems for the critics Chambers' deployment of phrenology, his reference to the transmutation of oats into rye, and his acceptance of the experiments of Andrew Crosse and W H Weekes on spontaneous generation of simple organisms, met with either ridicule or confident dismissal.[48] However, where he dealt with more orthodox science, the reviewers had to enter into more extended argument

The response to Chambers' use of the "nebular hypothesis" was out of proportion to its place in the book Only the first chapter dealt with this, but the reviewers gave it considerable attention.[49] Chambers employed the ideas of William Herschel and Pierre Simon Laplace on

[47] One reviewer suggested that the references to foetal transformations were those which gave the author "his strongest hold on the popular mind, in favour of the development doctrines" ("Geology vs Development," *Fraser's Magazine*, 42 [1850], 371) For the significance of Chambers' embryological argument, see Hodge, pp 138, 142-146

[48] The fact that the *acurus Crosii* was an insect, and not a more simple organism, made the disbelief especially spirited But Chambers continued to stress the status of the evidence as experimental See his *Explanations*, pp 189-198 The spectre of Lamarck's evolutionary theory, which involved the notion of spontaneous generation, lay behind the scientific reaction in Britain See also John Farley, *The Spontaneous Generation Controversy* (Baltimore Johns Hopkins University Press, 1977), pp 69-70, 94-97

[49] For an account of Chambers' reaction to this criticism in successive editions, see M B Ogilvie, "Robert Chambers and the Nebular Hypothesis," *British Journal for the History of Science*, 8 (1975), 214-232

the possible formation of solar systems from primeval clouds of gas in order to assert that this cosmic process had its analogue in the history of organic life on earth [50] This speculative link had been made previously by John Nichol, an academic and writer of popular texts on astronomy In his *Views of the Architecture of the Heavens* (1837), Nichol spoke of nebulae as "fossil relics . the germs, the elements of that Life, which in coming ages will bud and blossom", he also stressed that "all things are in a state of change and PROGRESS "[51] Chambers reinforced these connections, arguing that astronomical theories of cosmic development were the prelude to a Law of Development in the organic creation (Chambers, *Vestiges*, pp 27, 153-154, 359-360) To his critics, therefore, an attack upon the nebular hypothesis had the appeal of an effective dismissal of the entire work.

The case of the nebular hypothesis, however, illustrates the difficulties confronting a public, scientific refutation of *Vestiges*. As in other sections of the book, Chambers was using recognized scientific literature and was able to quote respectable authorities in physical astronomy who favoured this theory. As one reviewer of *Vestiges* acknowledged, "the nebular hypothesis . . has assumed a shape and a consistency which forbids an entire rejection of it, which enforces our respect, and which, . . habituates the imagination to regard our planetary system as having probably been evolved, under the will of Providence, by the long operation of the established laws of matter" (W. H Smith, p 448). Indeed, before the appearance of *Vestiges*, some of its most notable critics — Brewster, Whewell, and Herschel — had not been unfavourable towards the "nebular hypothesis." Whewell, who first used the phrase in his *Bridgewater Treatise*, argued that, if properly conceived, it was compatible with natural theology In 1838 Brewster had given an account of Auguste Comte's version of the Laplacian hypothesis and found no necessary conflict with natural theology or Christian religion [52]

Not long after the publication of *Vestiges*, William Parsons, Lord Rosse announced that his new telescope had resolved some nebu-

[50] On the relationship between cosmic and organic evolution, see Ronald L Numbers, *Creation by Natural Law Laplace's Nebular Hypothesis in American Thought* (Seattle University of Washington Press, 1977), on Herschel, see Simon Schaffer, "Herschel in Bedlam Natural History and Stellar Astronomy," *British Journal for the History of Science*, 13 (1980), 211-239

[51] John P Nichol, *Views of the Architecture of the Heavens* (Edinburgh W Tait, 1837), pp 127, 206

[52] William Whewell, *Astronomy and General Physics considered with Reference to Natural Theology* (London W Pickering, 1834), pp 181-191, [David Brewster], "M Comte's Course of Philosophy," *Edinburgh Review*, 67 (1838), 297-301 Herschel's popular *Treatise on Astronomy* (London Longman, 1833), pp 401-408, carried a discussion of the nebulae, but not the theory of stellar evolution But for the view that Herschel presented it as a respectable theory, see Walter F Cannon, "John Herschel and the Idea of Science," *Journal of the History of Ideas*, 22 (1961), 234

lae, and this fact was used against Chambers But no major writers took this evidence as sufficient grounds for the rejection of the nebular hypothesis as an account of how stars and planets were formed Instead, it led to quite complex discussions which revealed the range of senses in which the hypothesis could be conceived John Herschel was anxious to distinguish his father's views from those of Laplace, and Brewster tried to separate Comte's elaboration of Laplace from that of Chambers.[53] To an extent, the complexities of these discriminations blunted the attack upon Chambers' deployment of this concept The different versions of the hypothesis,[54] and the fact that they were regularly conflated, made it hard to demonstrate to the public the "unscientific" character of the idea as it appeared in *Vestiges* On the other hand, Chambers was able to present his construal of the nebular hypothesis as a legitimate interpretation of a controversial topic (Chambers, *Explanations*, pp. 5-25) Whewell summarized the situation, remarking that "the various discussions which have taken place respecting the Nebular Hypothesis have tended . . to make it looked upon as far more probable than it really is" (Whewell, *Indications*, p 27). There was also a lack of uniformity in the response of the scientific community: whereas geologists such as Sedgwick, Aggassiz and Hugh Miller were quick to oppose all forms of evolutionary theory in astronomy, the leading astronomers, such as Herschel and George Airy, were far more restrained [55]

The most authoritative and detailed sections of Sedgwick's review focussed on the evidence from geology and paleontology which comprised the major part of the book Chambers derived his Law of Development from the discoveries of these sciences and it was data which could not easily be set aside In seeking to deprive Chambers of this support, Sedgwick argued that there were gaps in the fossil record and that there was no complete continuity from earlier simple to more recent complex species, such as the transmutation theory required [56] The specialists, including Darwin, appreciated this reply, but in terms of a public response to *Vestiges*, it had certain drawbacks For

[53] John Herschel, *British Association Reports* (London Murray, 1846), pp xxxvi-xxxviii, Brewster, "Vestiges," pp 476-477

[54] See Brooke, 'Plurality," pp 268-273

[55] See Walter F Cannon, "Herschel," pp 234-235 Mary Somerville, the author of astronomy texts, was not hostile in her response Thanking a friend for a copy of *Vestiges*, she wrote "I think it a powerful production, and was highly pleased with it, but I can easily see that it will offend in some quarters" (Somerville to W Grieg, 28 May 1845 in Martha Somerville, *Personal Recollections, from Early Life to Old Age, of Mary Somerville* [London Murray, 1873], p 278)

[56] [Adam Sedgwick], 'Natural History of Creation,' *Edinburgh Review*, 82 (1845), 29-64 Charles Lyell had made this point in criticizing Lamarck's theory in his *Principles of Geology*, 3 vols (London J Murray, 1830-1833)

example, in trying to undermine Chambers' thesis of development by natural law, Sedgwick incurred the risk of seeming to reject the progressive character of geological history. Yet this perspective was important to his own natural theology, and he had endorsed it when criticizing Charles Lyell's Uniformitarianism in 1831 and again in his *Discourse* of 1850, where it was associated with a teleological view of creation [57] Chambers forced Sedgwick to deny the *continuity* of progression and to stress the discontinuous aspects of organic creation because he had linked the idea of progress with that of transmutation

But the rejection of this hypothesis begged the question of a *scientific* alternative As Lyell understood, "the popularity of Vestiges arises from any theory being preferred to a series of miracles."[58] Indeed, some reviewers were quick to acknowledge this by indicating that they had no *a priori* objections to explanations of the development of organic creation by natural law (W H Smith, pp 449-451).[59] In his *Explanations*, Chambers was able to exploit this preference for natural explanation by shifting his focus from the substantive natural mechanism of evolution to a metaphysical commitment to the existence of general laws of nature (Chambers, *Explanations*, pp. 3-5, 147-149) [60] These two levels of proposition were not easily disentangled and, in attempting to oppose the doctrine of *Vestiges*, Chambers' scientific opponents ran the risk of seeming to prefer supernatural or miraculous to natural causes.[61]

In general, the range of its scientific content, its mixture of accredited evidence and marginal data, and its conflation of natural, moral, and metaphysical propositions made *Vestiges* a difficult target. Sound technical criticism could be levelled at specific sections, but often with the effect of granting them a degree of scientific status and with the larger result of leaving the general suggestion of the book only slightly damaged While specialist critics could shatter the analogies which Chambers advanced, the reading public saw them as fascinating

[57] Adam Sedgwick, *Addresses delivered at the Anniversary Meetings of the Geological Society of London* (London R Taylor, 1831), 23-25, Sedgwick, *A Discourse on the studies of the University of Cambridge*, 5th ed (London and Cambridge Barker and Deighton, 1850), pp ccxvii-ccxix

[58] Quoted in Leonard G Wilson, ed , *Sir Charles Lyell's Scientific Journals on the Species Question* (New Haven Yale University Press, 1970), p 84 For the status of the concept of miracle' in scientific thought, see Walter F Cannon, "The Problem of Miracles in the 1830s," *Victorian Studies*, 4 (1960), 5-32

[59] For strong support of Chambers on this point, see Baden Powell, *Essays on the Spirit of the Inductive Philosophy The Unity of Worlds and Philosophy of Creation* (London Longman, 1855), p vii

[60] See also R M Young, "Darwin's Metaphor Does Nature Select?" *Monist*, 55 (1971), 458-459

[61] Chambers was also able to point to a contradiction between Herschel s opposition to natural explanations of species change in his Presidential Address of 1845, and his earlier acceptance of the possibility See Chambers, *Explanations*, pp 54, 141-142

generalizations. If experts such as Darwin, Wallace, and Owen could express mild approval for the synthetic scope of the book, it is not surprising that, for non-scientists, including other intellectuals, this appeal survived the fire of the critics One clear illustration of this is the response of Frederick Myers, the Cambridge academic, who confessed to Whewell his sympathy for the book

> I cannot but recognize a certain superiority in the book which will keep it alive, and am disposed to think that after all the scientific and other errors are deducted there will remain such a residuum of originality and truth as will demand and obtain for it a protracted consideration The book is so far notable to me that it is the first sustained attempt to combine the highest results of astronomy, geology, physiology, and chemistry, into such a series as may serve to indicate, if not to demonstrate, the existence of a law of creation more general than any yet announced [62]

Apart from attacking the content of the book, critics also made its methodology a major target To some extent, this strategy of demarcation avoided the problem of explaining the technical details necessary for the rebuttal of Chambers' substantive scientific arguments However, it was not without other difficulties, because the case of *Vestiges* illustrated the need to define proper scientific practice in more precise terms than those conveyed by the usual invocations of Baconianism

Statements about scientific method carried strong normative connotations in the nineteenth century, because of intellectual traditions which associated the proper use of reason with moral virtue, and because spokesmen for the scientific community had presented method as the defining feature of the scientific enterprise [63] Although there were methodological disputes among men of science, there was a uniformity in the way method was linked with the values of hard work, patience, and humility, when presented to the public

Several critics had recourse to this rhetoric as a means of challenging the scientific credentials of *Vestiges* Sedgwick, for example, declared that the author was "not only unacquainted with any of the severe lessons of inductive knowledge, but has a mind apparently incapable of comprehending them" (Sedgwick, *Discourse*, p. xx) The author had reversed the proper order of scientific research by looking for resemblances before fully ascertaining the *differences* among phenomena This charge of methodological ignorance was made by

[62] Reverend Frederick Myers to Whewell, [] 1845, in Douglas, p 317

[63] On this theme, see Richard Yeo, "Scientific Method and the Image of Science, 1831-1891," in *The Parliament of Science The British Association for the Advancement of Science, 1831-1981*, eds Roy MacLeod and Peter Collins (Norwood, Pennsylvania Science Reviews, 1981), pp 65-88, and J A Schuster and R R Yeo, eds , *The Politics and Rhetoric of Scientific Method Historical Studies* (Dordrecht Reidel, forthcoming)

other reviewers the book's mode of reasoning was almost "childish," its use of analogy deficient, and its reliance upon hypothesis excessive (W H Smith, pp 449, 459) Both Sedgwick and Brewster also inferred a female authorship from the lack of disciplined attention to factual details· the inductive method demanded a masculine quality of mind capable of restraining the impulse to premature speculation (Sedgwick, "Natural History," pp. 3-4; Brewster, "Vestiges," p 503).[64]

The normative sanctions of this rhetoric depended upon the non-specificity of statements about method beyond general references to induction and Bacon. But Chambers was able to exploit this vagueness by using the Baconian tradition against his critics Thus, he argued that they had allowed theological dogma to determine their attitude to the question of transmutation so that they refused to recognize observations and experimental evidence. He castigated Whewell's idea of palaetiological sciences — those which studied origins but acknowledged a limit to natural explanations — as nothing but a mystification and a shackle on scientific research (Chambers, *Explanations*, pp. 126-130). Furthermore, Chambers was able to expose inconsistencies in statements by major writers about proper scientific methods, arguing, for example, that their criticism of his work as "hypothetical" contradicted the positive comments about the role of hypotheses made by authorities such as Herschel (Chambers, *Explanations*, pp. 179-180) In addition, the fact that Chambers did employ some respected scientific theories made it necessary for opponents to clarify the grounds of their methodolgical criticism in a way which revealed its connection with the issue of authority in science

Millhauser has interpreted the methodological objections to *Vestiges* in terms of a distrust of hypothesis and speculation, or the "Baconian particularizing spirit of most early-nineteenth-century science" (Millhauser, p. 144). This attitude was undoubtedly strong but the reaction to *Vestiges* was not simply a profession of empiricism. it was an attempt to restrict the privilege of theoretical speculation to a small circle of recognized researchers. The opposition to Chambers' thesis should not be referred to Baconianism, if this is meant to suggest a rejection of hypothesis in science.[65] The importance of hypothesis was

[64] Sedgwick told Lyell that women "have by nature a distaste for the dull realities of physical truth, and above all for the labour pains by which they are produced" (John W Clark and Thomas M Hughes, *Life and Letters of the Reverend Adam Sedgwick*, 2 vols [Cambridge Cambridge University Press, 1890], II, 85)

[65] The various meanings of Baconianism in the Victorian context would demand an extensive discussion which cannot be attempted here What can be said is that there was opposition to the Baconian notion that theoretical activity could be divorced from practical empirical investigation

not at stake: the issue was rather one of who was to be entrusted with theorizing On this point, there was full agreement among those who might have differed on other questions of method. the qualifications for theoretical speculation had to be of the strictest kind This position can be related to the division of scientific labour between amateur observers and the more elite group of theorists, a distinction that had been established in some sections of the British Association (Morrell and Thackray, pp. 268-275). One of the significant themes of the critical reviews was the complaint that *Vestiges* violated this principle: it was an attempt at grand speculation by an unrecognized amateur.

There is a sense in which the reaction to *Vestiges* was a criticism of the theorist as much as the theory. There are two dimensions to this claim Firstly, in the case of speculations, such as the nebular hypothesis, the strongest attacks were not directed against the hypothesis itself, but against the uses to which it was put Chambers was reprimanded for taking this hypothesis out of its proper context — physical astronomy — and extrapolating it to the realm of organic nature As Brewster remarked, the danger of the nebular hypothesis was magnified by the "use which has been made of it as a basis for other errors" (Brewster, "Vestiges," p. 479). Closely connected with this objection was the complaint that Chambers had taken a tentative hypothesis from the safe circle of scientific debate and proclaimed it "*to the world*" as a dogmatic doctrine (Whewell, p 25)

There was, secondly, a denial of Chambers' right to theorize. Chambers presented himself in the role of a theorist standing above the data of the various sciences, drawing them together into large generalizations One recent Darwinian scholar has suggested that the British scientific community, especially its geological and natural history sections, did not recognize a role for the "theorist" distinct from other participants of the scientific enterprise, and that this affected the way Darwin presented his theories to scientific audiences.[66] If the posture of the theorist was problematic in the case of a recognized researcher, it was clearly an improper role for Chambers because, as he frequently acknowledged, his qualifications were those of "a general student," not those of an expert (Chambers, *Explanations*, p. 103) For this reason, as Brewster explained, his theory was "not entitled to the privilege which we concede to the original inquirer" (Brewster, "Vestiges," p. 474).

[66] Sandra Herbert, "The Place of Man in the Development of Darwin's Theory of Transmutation, Part II," *Journal of the History of Biology*, 10 (1977), 157-171

Most critics branded the author of *Vestiges* as a novice and dismissed the work as being solely dependent on second-hand knowledge of science Thus, one reviewer predicted that if the author had "performed one single chemical experiment, and endeavoured to understand its import he would never have presumed to write this book" ("Vestiges," *British Quarterly Review*, 1 [1845], 507) Similarly, Huxley could sympathize with Sedgwick's indignation when confronted with a grand hypothesis from a man "who would have been an astronomer — but for sitting up at night; a geologist — but for dirtying his fingers" (Huxley, p. 438) These criticisms established practical scientific research as one of the preconditions for theoretical speculation From this perspective, the doctrine of *Vestiges* could be denounced as rash conjecture because its author did not evince the skills, knowledge, and reputation which derived from serious scientific research

It is therefore possible to see the reaction to Chambers as the affirmation of a philosophy of science which gave authority in matters of theory to those whose work had been sanctioned by scientific institutions On this view, theoretical speculation was dangerous if it did not proceed from thorough acquaintance with empirical data and if it was not guided by proper methodology Licence to theorize was denied to those who had not accomplished significant scientific work in a specialized area Brewster underlined one of the key issues when, in effect, he advised Chambers to specialize· to concentrate on some "little department of science" before seeking to "enjoy the luxury of generalization "[67] But this emphasis on detailed knowledge of a particular field meant that theories embracing material from several disciplines would become increasingly rare as specialization intensified It was this question of specialization, and its implications for the participation of laymen in science, which became the centre of Chambers' reply to his critics

V

In his *Explanations*, published in 1845 as a response to the criticism of *Vestiges*, Chambers launched an attack on the authority of "the scientific class." In effect, he refused to accept that the judgement of "scientific men" on particular parts of the book was sufficient to dis-

[67] [David Brewster], "Explanations of Vestiges of the Natural History of Creation," *North British Review*, 4 (1846), 504

credit his main theory He feared that this piecemeal criticism had distracted public attention from the general scope of the work But he then argued that it was precisely these general views which the "scientific class" were unable to appreciate because their research had become too specialized.

> They are, almost without exception, engaged, each in his own little department of science, and able to give little or no attention to other parts of that vast field From year to year, and from age to age, we see them at work, adding no doubt much to the known, and advancing many important interests, but, at the same time, doing little for the establishment of comprehensive views of nature Experiments in however narrow a walk, facts of whatever minuteness, make reputations in scientific societies, all beyond is regarded with suspicion and distrust
>
> (Chambers, *Explanations*, pp 175-176)

It is important to recognize that Chambers was not alone in expressing dissatisfaction with the current image of science In fact, some of the less critical reviews used the case of his book to comment on tendencies of scientific research and their effects. Thus, Edward Forbes, the naturalist, remarked that "for some time back we have been so immersed in the *facts* of science, that to read a volume of speculations is like a breath of fresh air to the workman in a crowded factory." Although critical of some of its scientific arguments, he concluded that "the great merit of the 'Vestiges' is, the attempt made to show the mutual bearing of sciences, at present too often regarded as far apart "[68] The *Westminster Review*, which carried articles on both *Vestiges* and *Explanations*, continued this theme It referred to the accumulation of unorganized facts produced by specialization and welcomed *Vestiges* as the "most skilful generalization" available about the natural world.[69] One of its writers concluded that "the error of the author of the *'Vestiges'* has been too general an acquaintance with loose scientific literature; the error of his antagonists has been too limited a knowledge of grand scientific views" (Crosse, p. 194)

The problem of specialization and its implications for the public image of science was recognized by the leaders of the scientific community. It had been noticed at the early meetings of the British Association in the context of discussions about the need to foster communication between researchers in different fields of science The Association was meant to facilitate this process and to give institutional

[68] [Edward Forbes], "Vestiges of the Natural History of Creation," *Lancet*, 2 (23 November 1844), 265-266

[69] "Natural History of Creation," *Westminster Review*, 48 (1847-48), 130 For another criticism of "the specialty of most scientific men," see George Henry Lewes, *Comte's Philosophy of the Sciences* (London H Bohn, 1853), p 13

expression to the unity of science But the existence of an expanding number of sections devoted to particular groups of sciences indicated the pressure of specialization Men of science committed to the ideal of general knowledge were sensitive to this development, and Whewell coined the word "scientist" in the context of these fears about the fragmentation of scientific knowledge [70] By the 1840s, this specialization was firmly established, and its consequences frequently noted [71]

The implications of this tendency were thought to be twofold firstly, that potentially fruitful interaction between different branches of science would not occur; and secondly, that it would become increasingly difficult for writers to present a general picture of all science to the lay public. G. C. Lewis, in his discussion of the exercise and recognition of scientific authority, warned that it was therefore "necessary that men of comprehensive minds should survey the whole circle of the sciences, should understand their mutual relations, . . to avoid that narrowing influence which is produced by restricting the mind to the exclusive contemplation of one subject" (Lewis, p. 112). Chambers was able to portray himself as one who had taken up this challenge by transcending the specialist horizons of the experts. As several reviewers suggested, this was the appeal of *Vestiges*: it offered a synthesis of recent ideas from several sciences and presented them under seductive generalizations such as the Law of Development. The frustration this produced in scientific authorities was epitomized by Whewell's reaction to positive comments about this feature of Chambers' book: "If the mere combining chemistry, geology, physiology, and the like, into a nominal system, while you violate the principles of each at every step of your hypothesis, be held to be a philosophical merit, because the speculator is seeking a wider law than gravitation, I do not see what we, whose admiration of the discovery of gravitation arises from its truth, and the soundness of every step to the truth, have to do, except seek another audience."[72]

Chambers was indeed seeking another audience. In replying to the attack upon his amateur standing, he argued that the scientific specialists were too narrow in outlook to offer an unbiased opinion on a

[70] [William Whewell], "On the Connexion of the Physical Sciences," *Quarterly Review*, 51 (1834), 59 On specialization, see Yeo, ' Scientific Method, pp 68-70

[71] Apart from capitalizing on the issue of specialization in *Explanations*, Chambers altered a passage in the "Note Conclusory" of the original edition of *Vestiges* in order to emphasize his role as a synthesizer attempting "to weave a great generalization out of the truths already established" (*Vestiges*, 4th ed [London Churchill, 1845], p 404)

[72] Whewell to Myers, 16 March 1845, in Douglas, p 318

general theory He concluded that "it must be before another tribunal, that this new philosophy is to be truly and righteously judged" (Chambers, *Explanations*, p 179) Confronted by "these extraordinary opinions," Brewster ridiculed the prospect of a work about the natural world, refusing the judgement of men of science and their learned institutions "If they be disqualified for the task," he asked, "is it from the Royal Society of Literature — from the Antiquaries . . or from a committee of Blue-stockings, that he is to summon the judges who are to preside at the grand inquest on this new philosophy?" (Brewster, "Explanations," pp 488-489). This was indeed a pertinent question because, having rejected the authority of the scientific community, Chambers was appealing to "ordinary readers" (Chambers, *Explanations*, p. 2)

In his attack upon the scientific establishment, Chambers constructed a dichotomy between a narrow, pragmatic physical science limited to specialists, and a broad, speculative natural philosophy in which all people could participate.[73] He condemned the "chilling repression of all saliency in investigation, which characterizes the scientific men of our country and age" (Chambers, *Explanations*, p. 179) In a description of the scientific ethos which many men of science would not have recognized, Chambers claimed that the values of science were becoming too pragmatic and utilitarian. The consequence was that the fundamental questions which people had about the natural world and their relationship to its Creator were not being addressed In this context, he appealed to the non-scientific public for a judgement on *Vestiges* and urged the need for a broad natural philosophy closer to the demands of society than the limited physical science of learned institutions. In this way, Chambers challenged the right of scientific authorities to restrict the scope of conjecture in science and proclaimed the right of the lay person to speculate in the field of natural knowledge. Against this view, scientific spokesmen were adamant that certain questions required specialist knowledge and could not be answered on the basis of general reading. Referring to the fossil record, Brewster asserted that "geologists alone are entitled to adjudicate upon such a question" (Brewster, "Vestiges," p. 485).

As we have seen, this assertion of the authority of practising scientists in their areas of expertise was a major theme in the response

[73] For a contrast between popular science and the image of pure science, which refers to the *Vestiges* dispute, see R G A Dolby, "On the Autonomy of Pure Science The Construction and Maintenance of Barriers between Scientific Establishments and Popular Culture,' in *Scientific Establishments and Hierarchies*, eds N Elias and H Martins (Dordrecht Reidel, 1982), pp 267-292

to *Vestiges*. But the debate also revealed the problems which confronted a definition of expertise in terms of first-hand knowledge, such as field research or experimentation Chambers was able to reply to the charge that he lacked this experience by showing that it was a simplistic conception of scientific knowledge Thus, he admonished Sedgwick for proclaiming that he had "*seen* what he speaks of" — namely, geological evidence against the development hypothesis — as if this "personal and direct observation of facts" immediately settled the question (Chambers, *Explanations*, pp 101-102) Such an attitude ignored the way in which scientific knowledge depended upon a dialogue between different interpretations of reported observations This response was possible because the increasing division of labour in scientific research was making the distinction between first and second-hand knowledge an inappropriate criterion of scientific authority. In this particular debate, it did not discriminate between Chambers and, say, Whewell, who had done little practical geology, or Brewster, who worked on optics. Chambers, like Whewell, was asserting the right to hypothesize and generalize about the results of scientific discoveries in various fields. But in addition to this, he claimed that the general public had a right to opinions in matters of science

Apart from Chambers, the most forceful exponent of this position was Francis Newman, who reviewed both *Vestiges* and *Explanations* for the *Prospective Review* Newman also resented the manner in which Sedgwick scorned the notion of second-hand knowledge. He agreed that the non-scientific public was dependent upon "physical professors" for facts and details, but stressed that "they must not be allowed to monopolize the functions of thought or philosophy" (Newman, pp 33-34). He was indignant about the implication that "practical geologists are to dictate concerning the Laws of Evidence; as if nobody but they could properly know what 'Induction' meant" (Newman, p 34) The proofs of science were not strictly demonstrative but were of the kind addressed to the "ordinary understanding," and debate about scientific theories should therefore contain all views. Newman realized that, in practice, this wider participation was limited and that "the public at large have the *unanimity of men of science* as the great guarantee of truth." But he stressed that the public confidence in this consensus was based on the assumption that "no authority [had been] allowed to domineer."[74] Like Chambers, he

[74] [Francis Newman], "Vestiges of the Natural History of Creation, *Prospective Review*, 1 (1845), 50

insisted that natural scientists should not be allowed to define the limits of debate or restrict the number of participants, even in the area of natural knowledge

It is interesting that Chambers' concern with the place of authority in science did not end with the controversy over *Vestiges* In an essay of 1859, his target was the "scientific scepticism" which rejected the everyday evidence of the senses whenever these conflicted with general laws of nature Although not clearly specified, it is likely that the occasion of this paper was the debunking of psychic phenomena by Michael Faraday and other prominent scientists Chambers understood Faraday to be claiming that the testimony of the senses could not be trusted and that there was "no safety but in a knowledge of the laws of nature "[75]

In Chambers' opinion, this attitude crippled scientific progress because it prevented the recognition of new facts. Reproducing his earlier critique, he suggested that the outlook of sceptical scientists arose from "habits of mind induced by exclusive dealing with one class of facts" physicists, for example, because they relied upon mathematical proofs, denigrated other forms of evidence. He also contended that natural laws were themselves based on a complex set of sense testimony and inference and were therefore not necessarily more certain than well-documented testimonies about specific occurrences (Chambers, *Testimony*, pp 2-9, 15, 22-24).

Given his earlier stress upon the efficacy of the laws of nature, this was a curious position to take. There is, however, an element of continuity between these two episodes. namely, his reluctance to allow scientific authorities to restrict speculation about the natural world In the defence of *Vestiges*, there was an appeal to the judgement of "ordinary readers" over the particular objections of specialists; in the essay relating to psychic research, there was a claim for the value of human testimony against the methodological standards of prominent scientists. By affirming the status of common observation in competition with the experimental methods of experts, Chambers was reserving a place for the untrained public in debates about natural knowledge

This article has suggested that the controversy over *Vestiges* involved not only scientific and theological issues, but questions concerning the social relations of science. It has shown how this debate

[75] [Robert Chambers], *Testimony Its Posture in the Scientific World* (London and Edinburgh Ward R Chambers, 1859), pp 1-2

was, in part, constituted by the related problems of popularization and specialization. These developments comprised the social and intellectual conditions which made the authority of science a significant issue in the mid-nineteenth century; and the rhetoric of both the scientific spokesmen and their opponents employed these concepts to advance alternative notions of authority in science The great popularity of *Vestiges* reinforced existing fears among leaders of the scientific community about public understanding of science and about the ways in which a variety of doctrines were represented as "scientific."

The task of distinguishing between science and pseudo-science in the case of *Vestiges* was complicated by its diverse content and by the problem of explaining its technical deficiencies to the lay public The synthetic character of the book was attractive as a counter to the increasing specialization of science which, in turn, made the task of effective popularization more difficult. Apart from attacking the substantive content of Chambers' book, the critics condemned it on methodological grounds. In doing so, they attempted to establish criteria such as practical research and specialist knowledge which invested authority in full-time experts. But the debate exposed difficulties in simple equations between first-hand knowledge and scientific authority and underlined the problem of formulating general methodological prescriptions for different disciplines.

Chambers was able to reply to both substantive and methodological criticisms, exploiting differences of opinion and perspective among scientific authorities Furthermore, in responding to those who wished to circumscribe the role of amateurs in scientific debate, he questioned the specialization of the scientific enterprise, arguing that it was not fulfilling its higher moral and cultural purpose. This response constructed a contrast between natural philosophy and physical science in order to assert the right of the lay public to speculate on general questions about the natural world, and, it rejected any exclusive claims to authority on the part of the scientific community. The arguments over Chambers' work therefore involved not only scientific data and theory, but rival conceptions of the scope and practice of science.

The controversy over *Vestiges* also reminds us of the historical nature of the language in which the social relations of Victorian science are often discussed. Although, in retrospect, it is tempting to explain this episode as a simple confrontation between "professional" and "amateur" science, it is necessary to recognize that these are

problematic terms In the mid-nineteenth century, science was still part of a general intellectual culture, and institutions such as the British Association catered for a broad audience. This meant that the limits of scientific debate were not narrowly defined — in addition to the technical content of a scientific work, its style, accessibility, and social implications were considered appropriate criteria. In this context, terms such as "professional" and "amateur," "specialist," and "popular" did not refer to readily accepted categories but were themselves an integral part of disputes about the proper form of natural knowledge This article has attempted to show that the relationships of authority which these dichotomies reflect were still being negotiated in the period in which Chambers' book appeared [76] It was not until about the 1870s, when the institutional and educational status of science became more secure, that the boundaries between an accredited scientific community and the lay public became clearly delineated. This did not mean that the problem of authority was resolved; rather, it assumed different forms. The ascendency of experts was established and the need to confront amateur speculation in public was not so urgent, but there were clashes between experts from different disciplines.[77] And with this greater specialization, the problem of responding to synthetic theories (illustrated by the case of *Vestiges*) became a significant issue in scientific debate [78] Finally, there was an intensification of the more general question of claims to cultural authority beyond the sphere of natural knowledge, as some sections of the scientific community sought to make British culture more "scientific."[79]

Griffith University

[76] For an analysis of a famous mid-nineteenth-century debate that raises interesting comparisons, see J R Lucas, "Wilberforce and Huxley A Legendary Encounter," *Historical Journal*, 22 (1979), 313-330

[77] For the clash between geologists and physicists, see J D Burchfield, *Lord Kelvin and the Age of the Earth* (New Haven Yale University Press, 1975), chap 3

[78] The theory of continental drift, proposed by Alfred Wegener in the early twentieth century, posed this kind of problem because it cut across several disciplines The work of Immanuel Velikovsky, which draws upon archaeology and mythology as well as physics and geology, is another example

[79] See Frank M Turner, "Public Science in Britain, 1880-1919," *Isis*, 71 (1980), 580-608

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Dorothy K. Stein

LADY LOVELACE'S NOTES: TECHNICAL TEXT AND CULTURAL CONTEXT*

IT IS A TRUTH NOW WIDELY ACKNOWLEDGED THAT THE COMPUTER WAS invented between 1819 and 1834 by the English polymath named Charles Babbage It is also widely held that the most important description and discussion of this machine was written by Byron's daughter, the Countess of Lovelace, herself a gifted mathematician But if the character of the inventor and the reasons for the long neglect and ignorance of his invention have been vulnerable to misunderstanding, the doubly poetic figure of Lady Lovelace, and her paper on Babbage's machine, have recently proved particularly susceptible to legendary development, both in popular accounts and in more technical journals

Several years ago, a high-level computer language, developed by the Department of Defense for military purposes, was rechristened ADA in her honor Commencing the preface to a monograph describing this language, Henry Ledgard stated.

> If Charles Babbage is to be regarded as the father of modern day computer technology, then surely the Countess Augusta Ada Lovelace, after whom this new language is named, must be remembered as its midwife
>
> It was she, the daughter of England's poet Lord Byron, who translated the work of the Italian Mathematician L F Menabrea, attaching her own scientific commentaries on the dissimilarities between the difference engine and the analytical engine It was Lady Lovelace, the great lady of computers, who delivered the notes and loosely organized writings of Babbage, with her own invaluable amendments, to a world not quite ready to receive them [1]

Ledgard may be a computer expert rather than an historian, but even Brian Randell, in a standard reference work on computer history,

* Research for this paper was carried out chiefly while the author was a member of the Institute for Historical Research, London

[1] Henry Ledgard, *Ada An Introduction* (New York Springer-Verlag, 1980), p iii

has described Lady Lovelace's paper as the "single most important paper on Babbage's Analytical Engine," and wondered why it was not more influential in Howard Aiken's early designs for the Mark I [2] Recent research is gradually bringing the account of Babbage's contributions to science and technology into focus, and more continuities between his work and the modern computer have been discovered than were previously suspected.[3] Still, the primary concern of many scholars with present instruments has led to an emphasis on the prescience and anachronism of his plans and ideas, to the neglect of relationships with the society in which he lived Babbage's own claims for the Lovelace-Menabrea memoir, furthermore, have been unquestioningly accepted "These two memoirs taken together furnish, to those who are capable of understanding the reasoning, a complete demonstration — *That the whole of the developments and operations of analysis are now capable of being executed by machinery*" (Emphasis in the original) [4]

In this paper, I would like to examine these claims more closely, and to argue that Ada Lovelace's addition — her "Notes" — were more a reflection of the mathematical uncertainty of the author, the political purposes of the inventor, and, above all, of the social and cultural context in which it was written, than a blueprint for a scientific development.

I

Babbage is gradually becoming recognized as one of the most important scientific figures of the nineteenth century He was born in London, in 1791, the only son of a banker, which made him decidedly a gentleman, though not an aristocrat He supplemented the instruction of teachers and tutors with a private study of mathematics so broad and deep that when he arrived at Cambridge he found he knew more than most dons Gathering a group of like-minded fellow students around him, he set out to reform the state of mathematics in England, which was far behind the Continent, particularly France,

[2] Brian Randell, ed , *The Origins of Digital Computers* (New York Springer-Verlag, 1973), pp 426, 187

[3] See A Hyman, *Charles Babbage, Pioneer of the Computer* (London Oxford University Press, 1981)

[4] Charles Babbage, *Passages from the Life of a Philosopher* (London Longman, 1864), p 136

partly as a result of the high veneration in which Isaac Newton was held The first campaign of Babbage and his friends was to persuade the University to adopt Gottfried Wilhelm von Leibniz's superior "d" notation for the differential calculus in place of Newton's fluxional "dots "

To accomplish this, they formed a society to translate Sylvestre François Lacroix's abridged work on the differential and integral calculus It was published in 1816, and, in recognition of the almost sacrilegious step they were proposing, Babbage facetiously suggested that they title their work "The Principles of pure D-ism in opposition to the Dot-age of the University" (*Passages*, p 29) Then, to encourage the languid dons to adopt it, they published a companion volume of problems with solutions, all in the new notation

Their campaign was successful, but, having left Cambridge, Babbage was unable to secure an appointment he considered worthy of his talents, one by one they fell to men of lesser acquirements. Cambridge University, he later wrote, finally forgave his irreverence by electing him to the Lucasian Chair of Mathematics, Newton's old post But the honor came so late (he had been passed over at his first application) that he almost declined it, his father, in whose eyes his refusal to accept lesser positions would have been vindicated by the appointment, was dead Then, too, he was already deep in work on his first calculating engine Before that, however, he had produced a series of papers which made highly original and important contributions to the development of modern algebra A recent assessment of Babbage's work in pure mathematics concluded that it was a thousand pities he had turned his attention to calculators in 1820, aborting this phase of his career [5]

According to Babbage's accounts, which differ in detail, the impetus behind the invention of his first machine, which he called the Difference Engine, was the need to produce error-free numerical tables of various kinds, a task which seemed beyond the capabilities of fallible human beings As skillful and inventive in practical matters as in theoretical, by 1822 he had constructed a small model which worked well enough to prompt him to write an open letter to Sir Humphry Davy, then President of the Royal Society, mentioning that he had actually thought of several different machines, suited to different types of mathematical computation

[5] See J M Dubbey, *The Mathematical Work of Charles Babbage* (Cambridge Cambridge University Press, 1978) Dubbey has pointed out that little of this work was published, but remained in manuscript Babbage's friend, George Peacock, however, incorporated some of Babbage's ideas into his own text on algebra, which was very influential

To accumulate and store the numbers, Babbage adopted the device which had been used by Blaise Pascal and Leibniz tall, vertical shafts or axes on each of which a large number of circular disks were stacked by means of holes through their centers The disks did not actually touch each other, but each could be independently turned around its axis by means of an attached toothed gear wheel Each wheel had ten teeth, corresponding to the ten divisions marked on the edges of the disks, one for each digit, 0 through 9 The digits on each disk had a value one decimal place higher than those on the disk below, so that an ordinary decimal number could be read off each column by reading down a vertical line from the top The number on any level could be changed independently by turning the disk The number on one column could be added to that on another by connecting the two columns through gear wheels and turning the disks of one until all the digits in the chosen vertical line were zeros The second column then held the sum of the two original numbers

A slight complication (in theory, but in practice a considerable stumbling block) was the occasional need to carry from one disk level to the one above when the sum of the two digits on the first level was greater than 9 Babbage worked out several clever mechanical schemes to accomplish this, of which he was very proud The overall operation of the Difference Engine depended on the fact that many mathematical functions can be approximated by several terms of a power series The successive values of the powers of any number, and the sums of the power series, can be arrived at by repeated additions of several orders of differences between terms. Thus, the Difference Engine worked by connecting a number of columns of disks together in such a way that the successive numbers on each were added to the column next in line The column on the starting end of the series of additions, which contained the highest order of difference used, always had the same constant number on it Unlike previous mechanical calculators, once the Difference Engine was set up for a particular task, it would proceed through the necessary steps without further human intervention; as long as the human operator continued to turn the handle at the top, it continued to churn out successive values of the mathematical function for which it had been adjusted. But almost at once, Babbage began to think of ways to generalize his machine.

After a leisurely delay of a year, he was awarded a gold medal by the recently formed Astronomical Society and a grant from the government of £1,500 to launch him on the construction of a full-sized

Difference Engine In keeping with his principle that a theoretically feasible plan should not be frustrated by mechanical deficiencies, he determined to build his engine of the finest available materials, by the most advanced techniques, in the hands of the most expert workmen At the recommendation of Marc Brunel, he hired Joseph Clement, who had been trained at the firm of Henry Maudsley, the cradle of the most highly developed mechanical engineering methods of the time Still, the Difference Engine project required that Babbage himself design many new and ingenious tools for making the parts he needed These tools, by law, belonged to Clement, the artisan, rather than Babbage, the designer and employer.

The government eventually contributed £17,000 toward the construction, which proved much longer and more involved than the first estimation had anticipated The support, however, was erratic and uncertain from the first (as government payments often were), and Babbage had frequently to advance money to Clement out of his own pocket In 1833 Babbage had a portion of the machine put together; it worked perfectly Shortly thereafter, a dispute over payments broke out between Babbage and Clement, who not only stopped work and laid off his assistants, but appropriated all the drawings and parts of the engine, except for what had been assembled. That portion had been removed to Babbage's house so that he could demonstrate its workings to admiring visitors

It was almost two years before he regained his plans and parts, and nine years before the changing governments could be brought to a definite decision respecting future support for the project In the meantime, his restless mind had continued to evolve the possibilities of a calculating engine that could transcend the limitations of the Difference Engine an Analytical Engine, capable of multiplication and division as well as addition and subtraction, able to perform any numerical calculation and needing no constant order of difference It was during this period that he made the acquaintance of Ada Byron.

She was Byron's only legitimate offspring, a month after her birth, her mother insisted on a permanent separation which effectively ended the poet's year-long marriage Shortly thereafter, he left England and never returned Ada's education was briskly paced and closely supervised by her possessive and domineering, but highly intellectual, mother She acquired a lifelong taste for learning and displayed an early interest in science, approved by Lady Byron This was fortunate because, following an attack of measles in early adolescence,

she was partially paralysed until she was nearly seventeen;[6] during much of this period, however, she was able to continue some of her studies At seventeen, the customary age at the time, she was considered sufficiently recovered to "enter the world" by attending her first London season It was then that she met Babbage, with whom, said her mother, she was delighted He responded to her delight in his usual fashion, by issuing an invitation to view his Difference Engine

A careless reading of the inaccurate reminiscences of Sophia De Morgan, a friend of Lady Byron's, furnishes the conventional picture of Ada's response on this occasion. "I well remember accompanying her to see Mr Babbage's wonderful analytical engine Miss Byron, young as she was, understood its workings, and saw the great beauty of the invention."[7] The engine that Ada and her mother went to view (with or without Sophia) was not the Analytical Engine, no model or portion of which existed until long after Ada's death. Ada did see the great beauty of the Difference Engine — she later called it the "gem of all mechanism" and borrrowed the drawings — but as to understanding it, contemporary correspondence reveals only Lady Byron's·

> We both went to see the *thinking* machine (for such it seems) last Monday It raised several Nos to the 2nd & 3rd powers, and extracted the root of a Quadratic Equation — I had but faint glimpses of the principles by which it worked — Babbage said it had given him notions with respect to general laws which were never before presented to his mind — For instance, the Machine would go on counting regularly, 1, 2, 3, 4, &c — to 10,000 — and then pursue its calculation according to a new ratio, which was, I *think*, 10,002, 10,005, 10,009 — but I am only certain that the numbers were no longer successive ones, and that their differences were neither in arithmetical nor Geometrical ratio, as far as I could apprehend — If this occult principle of change existed in the law according to which the machine was constructed, (for Babbage discovered it to be latent in the mathematical formula originally applied by him) it may be consistent with the *general* laws of our solar system that the sun shall not rise tomorrow — He said, indeed, that the *exceptions* which took place in the operation of his Machine, & which were not to be accounted for by any errors or derangement of structure, would follow a greater number of uniform experiences than the world has known of days & nights — There was a sublimity in the views thus opened of the ultimate results of intellectual power [8]

Lady Byron's letter reveals that Babbage had already been struck by the cosmological implications of his invention which he later elaborated in *The Ninth Bridgewater Treatise*, his contribution to natural theology He was very fond of mystifying his guests with the

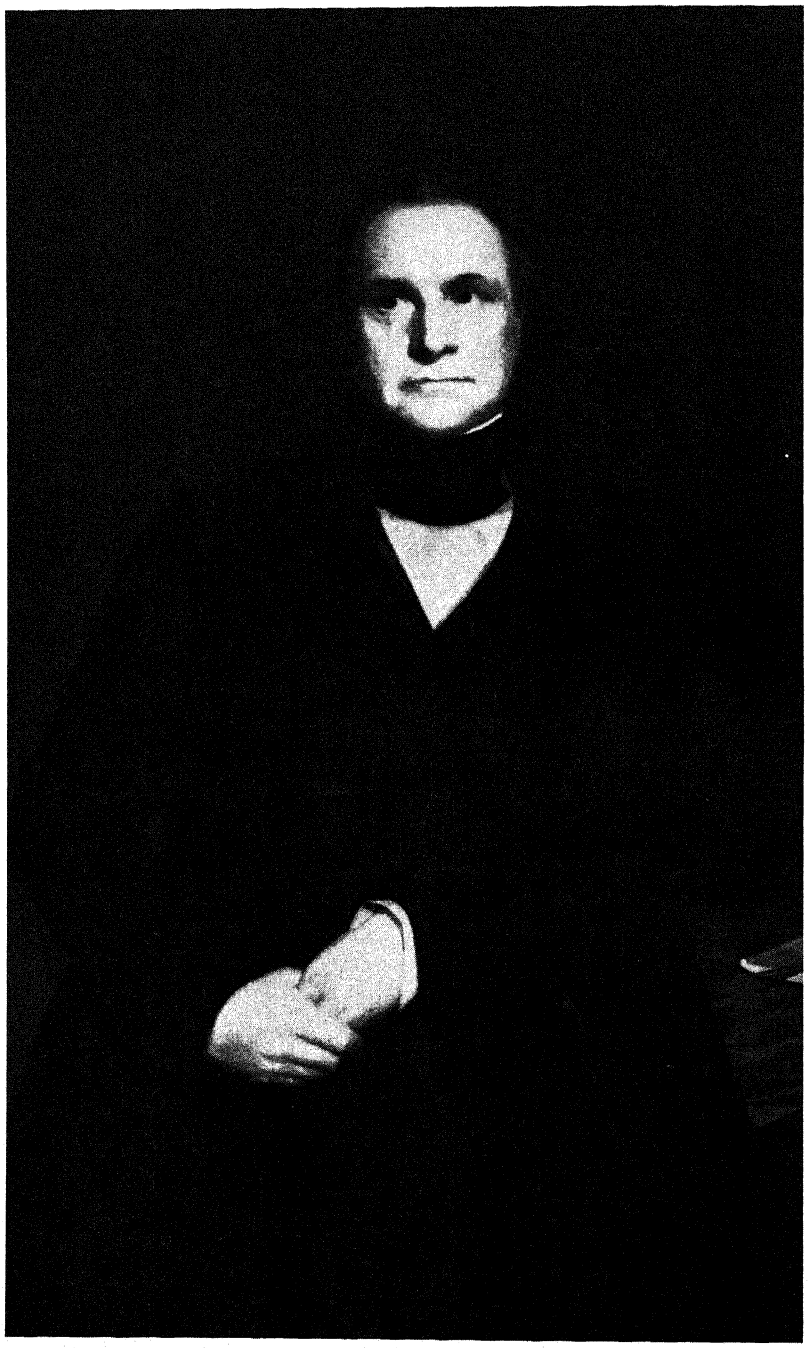
[6] A discussion of the nature of Ada's illness is outside the scope of this paper I suspect, however, that she may have been a victim of porphyria, and thus her paraplegia was connected with later episodes of a manic-depressive-like condition

[7] Sophia E De Morgan, *Memoir of Augustus De Morgan* (London Longman, 1882), p 89

[8] Lady Byron to Dr William King, 21 June 1833, L-B no 336. Lovelace-Byron Papers, Bodleian Library, Oxford Hereafter cited as L-B Extracts from the Lovelace Papers appear with the permission of the Earl of Lytton, Viscount Knebworth and the Lovelace Papers



(1) Ada, Lady King (later Lady Lovelace), 1835. To my knowledge, this has not been previously published, but clearly it was painted at the same time as her portrait by Margaret Carpenter exhibited at the Royal Academy, from which it differs slightly. Her comment on Mrs. Carpenter: "I conclude she is bent on displaying the whole expanse of my capacious jaw bone, upon which I think the word Mathematics should be written." She wished to be painted in her peeress's robes, although her mother felt it indicated an indelicate anticipation of the next coronation (*Murray Collection*).



(2) Babbage painted by S. Lawrence, 1845. His son commented that this portrait looked very like his father (*National Portrait Gallery*).

apparently miraculous behavior of the engine, but it was a simple matter for him to arrange that one or more additional number columns be coupled into the machine's operation after a set number of turns

Even before this date (1833), he had published his reflections on the connection of his invention with the economics of the industrial revolution. In 1827 Babbage's wife, two children, and his father died. Grief placed a strain on his health so severe that his doctors ordered an extended trip abroad His form of therapy included visits and surveys of as many factories and scientific establishments as he could take in One consequence of his industry was the publication in 1832 of *On the Economy of Machinery and Manufactures*, a major and influential work in economics that was later cited with respect by both John Stuart Mill and Karl Marx. It was a hymn to progress through industrial and technological development Two of its major themes were the division of labor and the processes of replication, and both were to be important in his designs for the Analytical Engine

II

As delighted as Ada might have been in meeting Babbage, and as interested as she was in science, she knew very little mathematics at the time It was not until the following year that she appealed to her mother's friend, Dr. William King, for help with "Euclid, Arithmetic and Algebra "[9] From time to time over the next few years she turned to Mary Somerville, another family friend and the celebrated translator of Pierre Simon de Laplace's *Celestial Mechanics*, for help with problems in trigonometry and solid geometry Then, late in 1839, she looked to Babbage for mathematical instruction He evaded her somewhat oblique suggestions, but in 1840 a congenial instructor was found in Augustus De Morgan, Sophia's husband

De Morgan, himself a key figure in the development of modern algebra, and the author of the first textbook in calculus to place the subject on a rigorous basis, was particularly delighted by Ada's fundamental philosophical questions, her "first queries" on new methods and ideas, as he called them He was so impressed by these that he scarcely noted her slow and erratic progress in acquiring real proficiency and understanding As for Ada, she had determined to become a scientific writer, and to collaborate with Babbage: "I am very anxious to talk to

[9] Ada Byron to Dr King, 9 March 1834, L-B no 172

you. I will give you a hint on *what* It strikes me that at some future time (it might even be within 3 or 4 years), *my head* may be made by you subservient to some of *your* purposes & plans If so, *if* ever I could be worthy or capable of being *used* by you, my head will be yours though I scarcely dare so exalt myself as to hope however humbly, that I can ever be intellectually worthy to attempt serving *you* "[10] But there is no evidence in the surviving correspondence on either side to suggest that he ever encouraged her wish until she laid before him a *fait accompli*

Babbage was certain that "as soon as an Analytical Engine exists, it will necessarily guide the future course of science" (*Passages*, p 137), but some of his contemporaries lacked his vision, including some, such as the Astronomer Royal, who were in a position to advise the government In his strenuous attempts to convert politicians to his faith and obtain the support he needed, if he did not want collaborators he certainly needed friends and promoters to keep the educated public appraised of new developments, and to keep his engines alive in their eyes during the long weary years when he hoped for official backing or at least vindication. Although he himself was energetic in his efforts to publicize, he preferred, whenever possible, to have discussion and praise appear over the names of others, particularly prominent others, even if sometimes he had to do the actual writing himself

In 1840 Babbage went to Turin to hold forth in a series of lectures and discussions explaining the proposed Analytical Engine to a group of Italian philosophers and men of science. He had hoped to have the most eminent of them, Giovanni Antonio Amadeo, Baron Plana, write a report or article on the subject, but Plana pleaded ill health. In the end he had to content himself with the services of a young military engineer, Captain Luigi Menabrea (who eventually became Prime Minister of Italy). Babbage accepted the substitution with less than consummate grace. From Florence, over a year later, he drafted a letter to Plana: "If you had made a report on the subject to the Academy of Turin during the last year it might have been of special service to me in the discussion of the question with my own government. As it is I must be content with the description drawn up by M Menabrea with which I am well satisfied because he seems to have penetrated completely the principles in which it rests" (Add Mss. 37, 191, f. 645).

From this it may be seen that Babbage had reviewed Menabrea's

[10] Ada (Byron) Lovelace to Charles Babbage, 12 January 1841, Add Mss 37,191, f 543 British Library Additional Manuscripts, London Hereafter cited as Add Mss

article over a year before it was published (It appeared, in French, in the *Bibliothèque Universelle de Genève* in October, 1842.) Correspondence from Menabrea indicates that it was rewritten to incorporate Babbage's suggestions before publication (27 January 1842, Add. Mss. 37,192, f 22) Shortly thereafter, Ada translated it into English, apparently at the suggestion and under the supervision of Charles Wheatstone, the physicist Wheatstone was yet another family friend who took a great deal of sympathetic interest in Ada's plans, constituting himself a sort of career adviser He also solicited translations for *Taylor's Scientific Memoirs,* a recently founded journal devoted to making available significant scientific and technical papers from abroad.

Babbage suffered a serious illness in the autumn of 1842, which may partly explain his being unaware of Ada's translation until after it was completed, and why her contribution took the form it did His role in the publication developed only later in the proceedings. According to his memoirs, when Ada told him what she had been up to, his response was to ask

> why she had not herself written an original paper on a subject with which she was so intimately acquainted? To this Lady Lovelace replied that the thought had not occurred to her I then suggested that she should add some notes to Menabrea's memoir, an idea which was immediately adopted
>
> We discussed together the various illustrations that might be introduced I suggested several, but the selection was entirely her own So also was the algebraic working out of the different problems, except, indeed, that relating to the numbers of Bernoulli [*sic*], which I had offered to do to save Lady Lovelace the trouble This she sent back to me for an amendment, having detected a grave mistake which I had made in the process
>
> (*Passages,* p 136)

Babbage's references to Ada were always kind, deferential, and flattering But his autobiography was written twenty years after the events referred to her, and his statements must be checked against other, more contemporary evidence The autobiography itself was a polemic on behalf of his machines, as he explains there, and he had every inducement to rate highly the most important piece of propaganda concerning his masterpiece The homage due to Babbage's immense and growing reputation, the awe inspired by his prodigious abilities, has tended to compel acceptance of almost any statement he cared to make about his inventions. However, when these statements are compared with the paper itself, and with the correspondence that accompanied its writing, a very different picture emerges In particular, Babbage's contribution to Ada's Notes is of interest in examining the ideas they contain.

To begin with, how well was she prepared to write on a mathematical subject? And how intimate was her acquaintance with Babbage's as yet immaterial engine? Her mathematical studies with De Morgan appear to have petered out late in 1842 The last surviving letters in that correspondence are dated the 16th and 27th of November of that year — hence shortly before she began work on the translation They show her wrestling with a simple and straightforward problem in functional equations, still unable to grasp the technique of substituting a new expression back into an equation, even when the correct formula to substitute has been handed to her. It was just such problems which had bedevilled her queries to Mary Somerville seven years previously, and several of her earlier letters to De Morgan In her letter of 27 November she sighed· "These functional equations are complete Will-o-the Wisps to me. The moment I fancy I have really at last got hold of something tangible & substantial, it all recedes further & further & vanishes again in thin air I *believe* I have left no method untried.[11]

The evidence of the tenuousness with which she grasped the subject of mathematics would be difficult to credit about one who succeeded in gaining a contemporary and posthumous reputation as a mathematical talent — if there were not so much of it — but perhaps the most telling and consequential piece occurs in her translation of Menabrea's portion of the memoir In one passage, Menabrea was considering a product which "becomes equal to the ratio of the circumference to the diameter" when n, the number of factors, becomes infinite The translated passage continues. "Nevertheless, when the cos of $n = \infty$ has been foreseen, a card may immediately order the substitution of the value of π "[12] Where did "the cos of $n = \infty$," which makes nonsense out of this passage, come from? In the original paper, the passage reads: "Cependant, lorsque le cos de $n = \infty$ a été prévu," and Ada made a literal translation of this. But a moment's consideration makes it clear that "cos " is a printer's error, and the expression intended by M Menabrea was "le cas de $n = \infty$" [the case of $n = \infty$], which makes sense in the context. In other words, Ada translated a printer's error, her mistake, surprisingly enough, has been reprinted several times [13]

[11] Ada (Byron) Lovelace to Augustus De Morgan, 27 November 1842, L-B no 170, f 149

[12] Sketch of the Analytical Engine invented by Charles Babbage Esq by L F Menabrea, of Turin, Officer of the Military Engineers [Translated and with notes by A A L Augusta Ada, Countess of Lovelace], Article XXIX, *Taylor's Scientific Memoirs*, 3 (1843), 687 Hereafter cited as *Memoir* The expression referred to is related to "Wallis' Product "

[13] H P Babbage, ed , *Babbage's Calculating Engines* (London Spon, 1889), and P Morrison and E Morrison, *Charles Babbage and his Calculating Engines* (New York Dover, 1961) B V Bowden, ed , in *Faster Than Thought* (London, Pitman, 1953), corrected the error without comment, along with a number of printer's errors in the Notes

Ada's understanding of the projected mechanical and logical design of the Analytical Engine early in 1843 is at least equally dubious. As fascinated as she had been by the Difference Engine, her letters show that during the early years of marriage and motherhood, which for her began in 1835, she had not kept *au courant* of developments in the Analytical Engine, which in any case would not have been easy Not only were Babbage's plans continually changing, but the direction of change was not always toward completion On 29 November 1839, for example, he wrote her, "I have just arrived at an improvement which will throw back all my drawings full six months unless I succeed in carrying out new views which may shorten the labour" (L-B no 168)

An even more telling instance occurred, once more in the translation of Menabrea, when Ada observed in a footnote that she had altered a sentence "in order to express more exactly the present state of the engine " In the original, the sentence read: "All the parts, all the wheels which constitute that immense mechanism have been put together, their action has been studied, but it has not yet been possible to assemble them."[14] In Ada's translation, we read instead. "The plans have been arranged for all the various parts, and for all the wheelwork, which compose this immense apparatus, and their action studied; but these have not yet been fully combined together in the drawings and mechanical notation" (*Memoir*, p 690) In the time between the writings of these two statements, the engine seems actually to have dematerialized In the early 1840s, only Babbage can be said to have been "intimately acquainted" with his engines, and although both of his interpreters were relative novices, completely dependent on him for information and claims about the Analytical Engine, Ada, from friendship and close association during the writing, must have been the more persuadable.

III

An article on Babbage's Difference Engine had been published in 1834 It was written by Dr Dionysius Lardner, a science popularizer, under Babbage's close supervision Along with urging the practical need for a machine to produce infallible numerical tables, and

[14] Notions sur la Machine Analytique, par Mr L-F Menabrea, capitaine du genie militaire, *Bibliothèque Universelle de Genève*, 41 (1842), 376 The translation of this sentence is my own

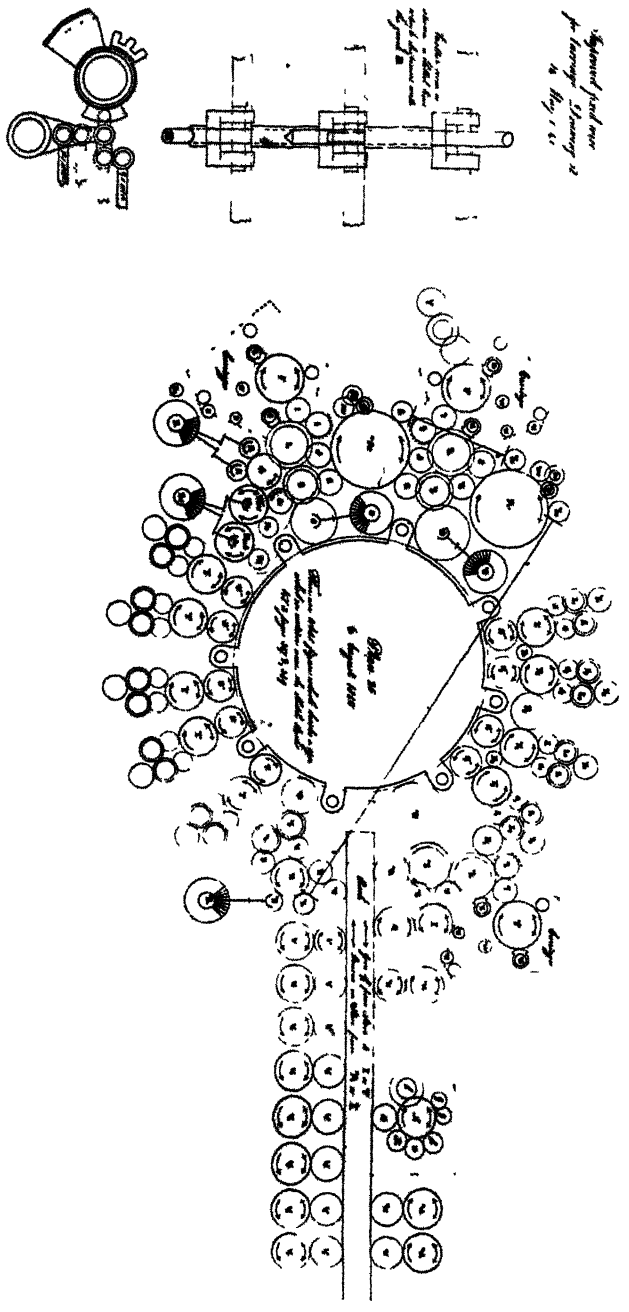
discussing the then current status of Babbage's negotiations with the government, it had included a description of the machine's physical structure and mechanical operation. By contrast, in keeping with the more general nature and immaterial status of the Analytical Engine, Menabrea's account dealt little with physical and mechanical details Instead he described the functional organization and mathematical operation of this more flexible and powerful invention. To illustrate its capabilities, he presented several charts or "Tables" of the steps through which the machine would be instructed to pass in performing its calculations These steps were to be punched in coded form on cards to be fed into the engine, hence, the charts constituted the first computer programs Menabrea's charts were taken from among those brought by Babbage to Turin to illustrate his talks there [15]

Babbage suggested several more "illustrations" to be included in Ada's Notes, that is, several more of the charts, with attendant discussion of the means of preparing the problems for machine processing The illustrations she used, except for "that relating to the numbers of Bernoulli," were also among those that Babbage had prepared some years earlier — a circumstance that explains the absence of discussion of these other illustrations in the correspondence which flew between Ada and Babbage while she was writing the Notes.

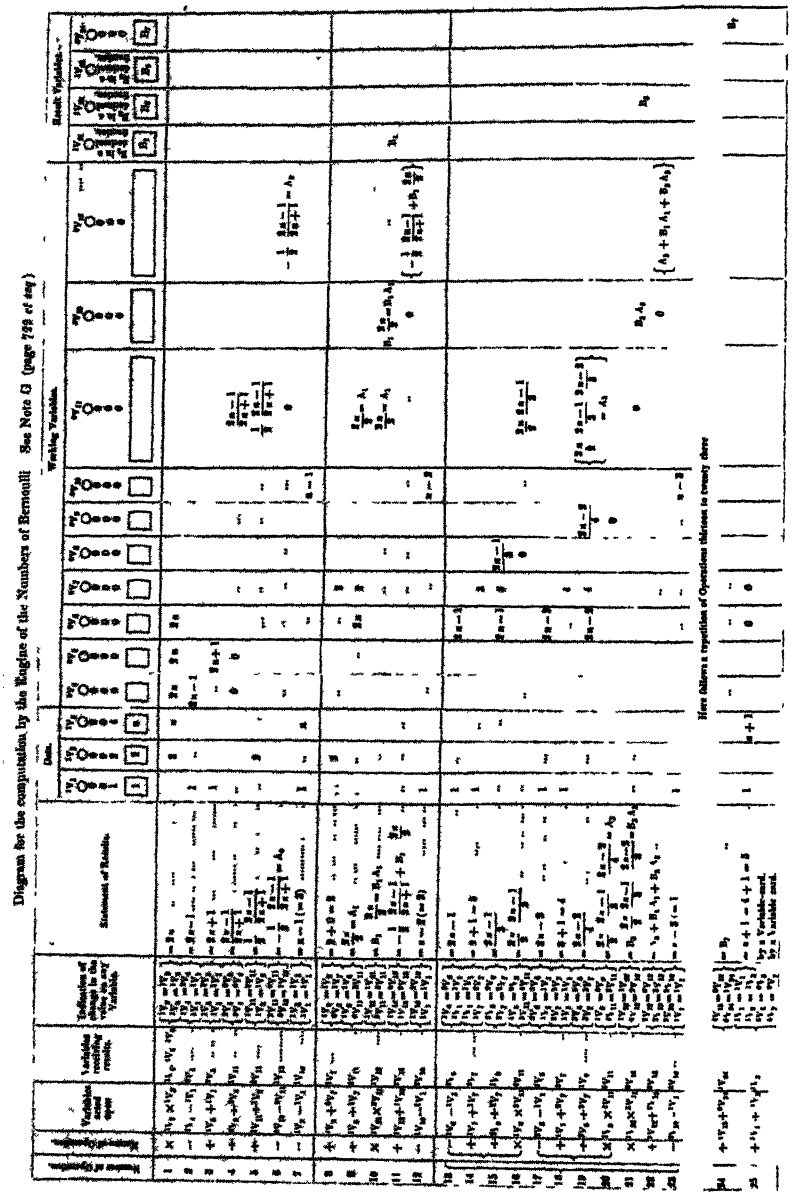
If Menabrea's account of the Analytical Engine was often on a more general and abstract plane than Lardner's description of the Difference Engine, Ada's Notes frequently moved to a level yet more rarefied and detached from the machine's proposed physical embodiment, to expatiate on the metaphysical implications and latent powers of an entire mental industry Here she seemed to be in her element With her usual painstaking thoroughness, she had set out to remedy her ignorance by reading all of Babbage's relevant papers An early letter in the series asks: "I have read your papers over with great attention, but I want you to answer the following question by return of post. The day I called on you, you wrote on a scrap of paper (which I have unluckily lost), that the *Difference* Engine would do (something or other) but that the Analytical Engine would do (something else that is absolutely general) Be kind enough to write this out properly for me; & then I think I can make some *very* good Notes."[16]

[15] I am indebted for information regarding the programs Babbage took to Turin to Dr Allan Bromley, Basser Department of Computer Science, University of Sydney, Australia, who in addition permitted me to see a prepublication copy of his introduction to a new edition of *Babbage's Calculating Engines* Lardner's account appeared in the *Edinburgh Review*, 59 (July 1834), 263-327

[16] Ada (Byron) Lovelace to Charles Babbage, n d , Add Mss 37,192, f 357.



(3) Plan showing the projected arrangement of the number columns in the 1840s The circular arrangement was abandoned before a model of the arithmetic unit ("mill") was built in the 1870s (*Science Museum, London, Imperial College Library*)



(4) The diagram or "program" for the computation of the first seven Bernoulli Numbers that was included in the Menabrea-Lovelace Memoir (*The British Library*)

As they are presented in the published memoir, Ada's Notes appear to be comments on specific points of Menabrea's paper, clarifying, elaborating, extending, and, occasionally, correcting, the translated portion However, the Notes are unified and set off from the translation by a set of recurrent themes appearing in a variety of contexts, and on different levels of abstraction One frequently repeated theme was the contrast between Babbage's two engines Where Menabrea had remarked that the Difference Engine "gave rise to the idea" of the Analytical Engine (which was both chronologically and logically true), Ada denied the relationship, insisting that there was no necessary temporal or conceptual relationship between the two inventions She stressed instead the metaphysical differences The Difference Engine, she said, could do nothing but add and tabulate, hence, its entire significance rested in the numerical data it processed The Analytical Engine, on the other hand, maintained a strict separation between data and operations, which could be manipulated independently; hence, it transcended mere number Possibly, the Government's final decision in the previous year to abandon the Difference Engine made Babbage wish to focus public attention on his newer, superior, and still hopeful project

For the modern reader the important difference between the two machines is that the Difference Engine followed an unvarying computational path (except for the parlor games Babbage played for the benefit of visitors such as Lady Byron), while the Analytical Engine was to be truly programmable, and capable of changing its course contingent upon the results of intermediate stages in the calculation (This was a feature mentioned by Ada only in passing) Thus, modern interest in Ada's Notes has centered on the prototype programs they contained — a century before the actual construction of a programmable computer

The ideas expressed, the themes stressed, however, show that the Notes were inspired by views that were more characteristic of the period in which they were written For Ada (and Babbage) the calculating engine was a metaphor as well as a harbinger of economic and scientific progress The theme stressed in presenting the "illustrations" or programs was that they demonstrate how certain lengthy, laborious, and complex calculations can be most efficiently executed — from the point of view of the human programmer or operator — by organizing the operations to be performed by the machine into repeated cyclical groups The same set of operations can then be repeated over and over by the engine, with only the starting and stopping places indicated by

the instructions. To describe this efficiency Ada used an interesting analogy taken from economic theory: "In the case of the Analytical Engine we have undoubtedly to lay out a certain capital of analytical labour in one particular line; but this is in order that the engine may bring us in a much larger return in another line" (*Memoir*, p. 698)

Where did this idea come from? Ada had referred to knowledge as capital early in 1841, when discussing her career plans with Sophia De Morgan: "Now the philosophy, the training, the instruments in short, I am as you know gaining I shall be years before I have the necessary quantity of what I call *capital* I am enterprising, & the greater & harder the work, the greater my spirit of enterprise "[17] But the full development of the calculating engine as a metaphor in economics had appeared in 1832 in Babbage's analysis of the industrial system, *The Economy of Machinery and Manufactures* There Babbage had reflected to the full his laissez-faire and utilitarian views He elaborated and extended the principles of the division of labor which had been illustrated by Adam Smith in *The Wealth of Nations*

The benefits derived from the division of labor, he explained, included not only the time saved and skill attained by each worker when restricted to the repetition of a small set of simple operations, but, most important, the money saved in the hiring of less skilled labor, such as that of women and children, for jobs requiring little strength or training A plentiful supply of cheap and available labor is also assured by this means: "Again, the facility of acquiring skill in a single process, and the early period of life at which it can be made a source of profit, will induce a greater number of parents to bring up their children to it; and from this circumstance also, the number of workmen being increased, the wages would soon fall "[18] Babbage's language is so matter-of-fact and complacent as to leave no doubt of his approval But the example of the division of labor which intrigued him most was one of the division of mental labor, also, as it happens, inspired by Adam Smith's pin factory It had been devised by Baron Gaspard de Prony, and was adverted to (presumably with Babbage's approval) by Menabrea as a preliminary to his discussion of the Analytical Engine M de Prony had been commissioned by the French government to supervise the preparation of the new mathematical tables needed by a newly decimalized nation While considering how such a prodigious

[17] Ada (Byron) Lovelace to Sophia De Morgan, 1 March 1841, L-B no 171

[18] Charles Babbage, *On the Economy of Machinery and Manufactures* (London C Knight, 1832), p 132 Hereafter cited as *Economy*

task could be organized, he chanced upon a copy of Smith's book At once he determined to manufacture logarithms like pins.

He set up two workshops which would perform the same calculations, serving as a mutual check on accuracy Above them were two other sections of mental operatives The higher consisted of five or six of the most eminent mathematicians in France, charged with deciding which formulae would be best for use in the step-by-step calculation of the functions to be tabulated (They performed the programmer's task) These formulae were then passed to the second section, consisting of seven or eight competent mathematicians, who would substitute numbers into the formulae and then pass them to the third section (In other words, they performed the operator's task)

The third section consisted of sixty to eighty persons who performed most of the numerical work, using only addition and subtraction Babbage, in *Economy*, went on immediately to make the connection between this third section and his Difference Engine, and between the organization of calculations and that of a factory, now in terms of class (in both senses) as well as task

> From that part executed by the third class [i e , section], which may almost be termed mechanical, requiring the least knowledge and by far the greatest labour, the first class were entirely exempt Such labour can always be purchased at an easy rate The duties of the second class were yet in some measure relieved by the higher interest naturally felt in these more difficult operations , but when the completion of a calculating engine shall have produced a substitute for the whole of the third section of computers, the attention of analysts will naturally be directed to a new discussion of the methods
> (*Economy*, p 157)

While it replaced the laboring class, the calculating engine would produce fresh and more challenging work for the best trained and most gifted men That class in both senses is intended is clear, for Babbage went directly on to state: "The proceeding of M Prony much resembles that of a skilful person about to construct a cotton or silk-mill, or any similar establishment Having, by his own genius, or through the aid of his friends, found that some improved machinery may be successfully applied to his pursuit, he makes drawings and may himself be considered as constituting the first section He next requires the assistance of operative engineers and these constitute his second section" (*Economy*, p 157) And once more an easily replaceable third section would actually perform most of the work, at least at first. Like Leibniz, Babbage deplored the waste of brilliant, educated men in routine, boring drudgery, for which he claimed the uneducated were better suited "It is remarkable that nine-tenths of this class had no knowledge of arithmetic beyond its first two rules which they were

thus called upon to exercise, and that these persons were usually found more correct in their calculations, than those who possessed a more extensive knowledge of the subject" (*Economy*, p 157)

When convenient, however, he saw no obstacle to replacing them by yet more accurate or efficient machinery (he disapproved of unions) He did not at first consider the displacement of the second section in this fashion, but once his work on the Analytical Engine began, he saw it could be assigned far more sophisticated tasks than the third section, and that the work of the second could be greatly simplified if not superseded Ada went further than Menabrea in suggesting what the Analytical Engine could be made to accomplish, but she rephrased Babbage's words of assurance for the men of Prony's first section, characteristically making a metaphysical virtue out of computational necessity "The Analytical Engine has no pretensions whatever to *originate* anything It can do whatever we *know how to order it* to perform It can *follow* analysis, but it has no power of *anticipating* any analytical relations or truths but it is likely to exert an *indirect* and reciprocal influence on science itself in another manner For, in so distributing and combining the truths and the formulae of analysis, that they may become most easily and rapidly amenable to the mechanical combinations of the engines, the relations and the nature of many subjects in that science are necessarily thrown into new lights, and more profoundly investigated This is a decidedly indirect, and a somewhat *speculative*, consequence of such an invention" (*Memoir*, p 722)

IV

In what might be the earliest of the letters written by Ada to Babbage concerning her preparation of the Notes, she said: "I want to know also something about how you manage the *imaginary* quantities; because as they are *nonsense* when supposed to be numbers; & as your results are wholly *numerical*, & your engine is a strictly *numerical* engine, I do not see my way there. Likewise *what* is the nature of the views you allude to (page 96, 97 of your Bridgewater), '& I was well aware that the mechanical generalisations &c, &c — which would lead &c&c' I particularly want to know to *what* that is wholly new, & valuable, you can allude, as being likely to be developed by the engine "[19] Ada's dependence on Babbage as sole authority on his

[19] Ada (Byron) Lovelace to Charles Babbage, Add Mss 37,192, f 370

machine clearly did not prevent her from making her usual challenging "first queries" on unfamiliar subjects, but it must have contributed to her susceptibility to being fobbed off with inadequate answers. Babbage's answer to this letter has unfortunately not survived

The question about imaginary numbers is a curious one Although mathematicians had for long been reluctant to accept them as inherently as "real" as the more conventional kind, it was well recognized that they could be used in computations as pairs of numbers, and hence were quite amenable to numerical methods, though a bit more complicated to manipulate During her studies with De Morgan, a good deal of attention had been devoted to this topic, which was of special interest to him But what is really interesting about this query, in the light of the comments she subsequently made in her Notes, is that, having been struck by the "strictly numerical" nature of the planned engine, she was somehow induced to change her mind.

The statement in *The Ninth Bridgewater Treatise* to which Ada referred ran "and I was well aware that the mechanical generalisations I had organised contained within them much more than I had leisure to study, and some things which will probably remain unproductive to a far distant day "[20] Ada devoted much space in her Notes to suggesting the implications of the "mechanical generalisations" of the Analytical Engine. Many of these derived, actually or metaphorically, from the physical separation between the operating part of the engine and the numerical storage, on one hand, and between the punched card instructions for operations, on one hand, and the orders for numerical storage and transfer on the other These separations had both cognitive and cosmological significance. About the first, she said. "It were much to be desired that when mathematical processes pass through the human brain instead of through the medium of inanimate mechanism, it were equally a necessity of things that the reasonings connected with *operations* should hold the same just place as a clear and well-defined branch of the subject of analysis, a fundamental but yet independent ingredient in the science, which they must do in studying the engine" (*Memoir*, p 692)

Although Ada defined "operation" with great generality, in fact the "operations" of the engine were planned to be the four arithmetic operations What is being alluded to in the passage above, however, is that the development of the infinitesimal calculus, the core of

[20] Charles Babbage, *The Ninth Bridgewater Treatise* (London Murray, 1838), pp 96,97, i e , 98,99 Hereafter cited as *Bridgewater*

"analysis" (which took place before, and independently of, its establishment on a rigorous basis) arose from the analogy between the rule of summation of exponents and the effects of the repeated iteration of other types of functional operation, such as differentiation The method of separation of symbols permitted the symbols of function or operation to be detached from the symbols or numbers on which they operated, and separately manipulated, applying this analogy [21] Babbage's work on the theory of functions was heavily dependent on such analogies (see Dubbey) Thus, it is interesting (and significant) to find Ada continuing her polemic on the superiority of the Analytical Engine in these terms.

> The calculus of operations [or theory of functions] is likewise in itself a topic of so much interest, and has of late years been so much more written on and thought on than formerly, that any bearing which that engine, from its mode of constitution, may possess upon the illustration of this branch of mathematical science should not be overlooked Whether the inventor of this engine had any such views in his mind while working out the invention, or whether he may subsequently have regarded it under this phase, we do not know, but it is one that forcibly occurred to ourselves We cannot forbear suggesting one practical result , we allude to the attainment of those combinations into which *imaginary quantities* enter This is a branch of its processes into which we have not had the opportunity of inquiring
>
> (*Memoir*, p 694)

But Ada had had, as we have seen, every opportunity of inquiring into these points, and had done so We will return to the significance of her falsehood

She herself, meanwhile, passed from the practical to the speculative to the cosmological: the same "just" separation was reflected in the design of the universe. "When it is remembered that this science [mathematics] constitutes the language through which alone we can adequately express the great facts of the natural world, . those who thus think on mathematical truth as the instrument through which the weak mind of man can most effectively read his Creator's works, will regard with especial interest all that can tend to facilitate the translation of its principles into explicit practical forms" (*Memoir*, p 696)

The view that mathematical truths were a direct revelation of God's way of thinking had been on the wane for well over a century, but in the rapid technological and social changes that were taking place in the nineteenth century, almost any scientific discovery could be scrutinized for its implications for religious belief There was much

[21] See E Koppelman, "The Calculus of Operations and the Rise of Abstract Algebra," *Archive for History of Exact Sciences*, 8 (1971), 155-242

interest in demonstrating that scientific activity could lead to a strengthening rather than a weakening of faith The Bridgewater Treatises were commissioned with this aim in mind. In 1829 the Earl of Bridgewater died leaving £8,000 to be distributed by the President of the Royal Society to authors nominated by him to produce works "On the Power, Wisdom and Goodness of God as manifested in the Creation " Babbage, a sharp critic of the Royal Society, was not among the eight authors so chosen Undeterred as usual, whenever he had a contribution to make, he wrote and published *The Ninth Bridgewater Treatise* as his and his engines' statement on natural theology

While the officially selected authors focused on some aspect of the physical or biological universe as a miracle of God's design, Babbage chose to consider the design of miracles Among his illustrations of the ways in which a really clever God could perform miracles, he pointed to the possibility of adjusting his Difference Engine in the manner which had so impressed Lady Byron: it could calculate a million terms of some regular progression, then produce an aberrant term on the million and first After that it could return to the original series, continue with the new one, or proceed to some other. In like manner the Analytical Engine could change its operations in accord with a previously planned set of punched cards How much more estimable, he asked, must we consider a God who programmed the universe to behave in this manner, with miracles preplanned from the beginning, than One who must be continually adjusting and intervening in the workings of His mechanism? He recommended his Treatise to the attention of Queen (then Princess) Victoria as a work favorable to religion

Was he serious? Despite his scorn of piety, it seems he was. Ada and Mary Somerville considered him so from the beginning. Even before Ada had read it, she wrote to Mrs. Somerville.

> I am longing to see Mr B's book From Mama's accounts of it it is a pity it was written in such haste & is so fragmentary & undeveloped in its character It seems to resemble one of those curious *multum in parvo* algebraical expressions of which you know infinitely more than I do, which under a few symbols involve & indicate to the initiated quantities endless in their complication & variety of mutual relations But *what* a pity that such a mind has not in some degree filled up the crude outlines for the benefit of those who could not! I fear the work will be underrated, and the circumstances you mention of the extreme haste fully accounts for this, though it in *fact* enhances its merit & indicates the more what it might be — However, I am criticising what I have not read I think when I *have* read it I shall probably give my opinion to Mr B himself Would this be presumptuous do you think?[22]

[22] Ada (Byron) King to Mary Somerville, 22 June 1837, Somerville Papers, Bodleian Library, Oxford, Dep c 367 The collection of Somerville Papers is owned by the Fairfax-Lucys and has been arranged and catalogued by Professor Elizabeth C Patterson

Babbage himself later presented a copy to her Perhaps she saw in her work on the Notes an opportunity to fill in the outlines Much of her comment on the significance of the Engine is on such an exalted metaphysical plane as to make hers actually the more mystical of the two accounts

V

Most of the time Babbage devoted to his engines was necessarily taken up in working out to the minutest details his plans for the arrangement and construction of the physical realization of his grand visions These were so complex that he had invented a system of mechanical notation or symbols to keep track of and coordinate all the moving and stationary parts at every moment during the cycles of calculation In the area of physical mechanism, his ideas were so concrete and practical that he plausibly argued that the by-products of his industry, in the form of improved tools, engineering practices, and training given to the machinists and draftsmen he employed, more than justified the investment of the government all by themselves

In contrast to this daily involvement, the Menabrea-Lovelace memoir dealt little with physical and mechanical details, and his discussions with its authors gave him scope to expand upon his visions With authors so young and impressed by his genius, the temptation to suggest functions or capabilities of the engine which were not quite worked out must have been great Alone on an entirely new frontier, Babbage was ever an optimist, and ever underestimating the time necessary to complete his plans He had, for example, assured both writers that the process of division, like the other arithmetic operations, could be executed by the machine on command. Yet, in a letter to Ada dated 30 June 1843 (while she was nearing the end of the Notes), he revealed he was still having difficulties with some of the details. "I am still working at some most entangled notations of Division but see my way through them at the expense of heavy labour, from which I shall not shrink as long as my head can bear it" (L-B no 168)

In addition to their relative freedom from consideration of the limitations imposed by mechanism, and Babbage's own tendency to enthusiasm and optimism, another circumstance must have contributed to the exuberance of the claims made for the engine by both authors, but especially by Ada This is the curious disingenuousness by which both claimed not to have consulted the inventor about certain of

the conjectures they made. In both cases the disclaimers were made for specific points, but seem, by implication, to cover the entire memoir. And while these claims may have been technically true when written, they need not, as we have seen, have been true by the time of publication Babbage seems to have encouraged their claims and disclaimers, which had the effect of freeing both author and inventor from responsibility for the statements made Concerning Ada's first Note, in which her disclaimers and unfathered conjectures first appear, for example, Babbage wrote her, "I am very reluctant to return the admirable and philosophic view of the Anal Engine contained in Note A Pray do not alter it "[23] That Babbage did not hesitate to correct even small misrepresentations of his ideas is demonstrated in the same letter, for he goes on to say, "There is still one trifling misapprehension about the variable cards "

The conjecture which Menabrea attached to his disclaimer of consultation was on the manner of handling the signs of the numbers in the process of multiplication It turned out to be correct Ada, characteristically, took her conjectures farther. Why, she speculated, if the machine could automatically combine the plus and minus signs of pairs of numbers when they are multiplied together, could it not be arranged to deal appropriately with any other algebraic symbols that might accompany numerical multipliers? Why could not symbols themselves be multiplied or divided, added or subtracted? Why could not the machine do algebra? The suggestion was a plausible though imaginative extension, not only of the sign feature, but of the metaphysical hierarchy between the Difference and the Analytical Engines The development of modern algebra, as Ada must have known from her work with De Morgan and talks with Babbage (who were both among its founders), was based on the freeing of algebraic symbols from the presumption that they could represent only numbers, and on the subsequent elaboration of rules for the manipulation of symbols in the abstract The idea of a machine to transcend number had been in Babbage's thoughts for some years It was the next step in making a machine "think "

In a letter to Mary Somerville, dated 8 March 1836, he had spoken of having "a kind of vision of a possible developing machine "[24] This was even before he had decided to adopt punched cards Then, in

[23] L-B no 168 The punched cards were inspired by those used in the Jacquard loom

[24] Charles Babbage to Mary Somerville, 8 March 1836, Somerville Papers, Dep c 369

July of that year, ten days after that momentous decision was taken, he mused in his notebook.

> This day I had for the first time a general but very indistinct conception of the possibility of making an engine work out *algebraic* developments — I mean without *any* reference to the *value* of the letters My notion is that as the cards (Jacquards) of the calc engine direct a series of operations and then recommence with the first so it might be possible to cause the same cards to punch others equivalent to any given number of repetitions But these hole[s] might perhaps be small pieces of formulae previously made by the first cards and possibly some mode might be found for arranging such detached parts according to the powers of nine numbers and of collecting similar ones [the entry breaks off here] [25]

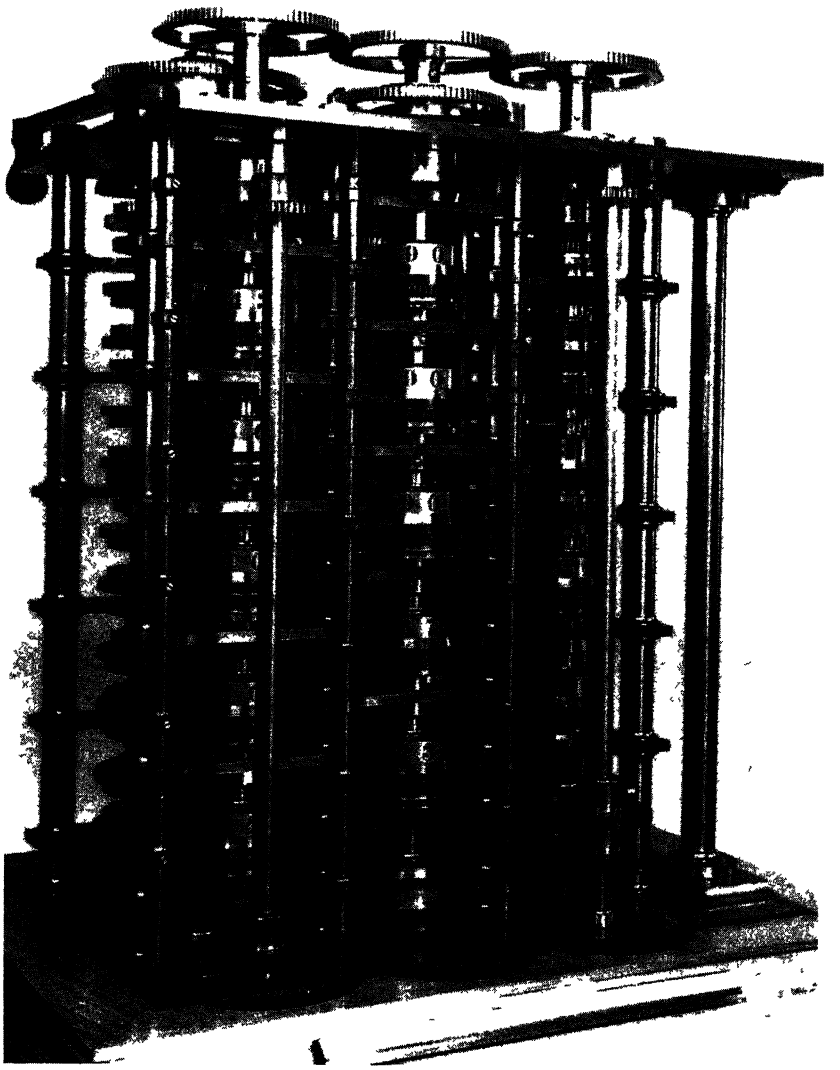
What he was groping for here was some means of bypassing or replacing the columns of stored numbers which were ordinarily the objects to be operated on so that he could operate on symbols instead

The crux of the difficulty lay in the very separation between operation and number over which the Notes expressed such pride In generalizing from the Difference Engine to the Analytical, Babbage had added a control system with a very different physical and conceptual basis from the number columns, which he retained The control was essentially a yes-no affair, that is, binary, while the columns were decimal Now he seemed to wish to operate on the binary-coded cards, on which could be punched codes for numbers, symbols, instructions, and locations; but, as Ada's account conceded, results could not be produced unless the system operated on the columns of decimally divided disks, with a seemingly intractable fixed interval between successive divisions It was this fixed relationship, not the inscription of digits on the edges of the disks (which were placed there only for the benefit of observers) that made the Analytical Engine "numerical "

There was also another sense in which the engine was "numerical." Babbage sometimes applied his knowledge of number theory (as well as algebra) to simplify the mechanism or shorten the projected time required to execute certain operations The representation of the plus or minus signs of the numbers as odd or even digits was actually one such "arithmetical artifice "[26] To have generalized beyond a few such specific instances would have required a recognition of a correspondence between number and symbol which Babbage's plans and the argument of the memoir show he was then moving away from In his notebook, in December 1837, Babbage returned to the problem, but

[25] Babbage's "Scribbling Books," Science Museum (Imperial College) Library, Kensington, London, vol 2, on Microfiche D3, 3/5, 10 July 1836

[26] Babbage, "On the Mathematical Powers of the Calculating Engine," in Randell, p 36



(5) Model of the Difference Engine put together in 1832 (*Science Museum, London*)

with less clarity than in the passage quoted above, and he concluded that it would "be better to construct a new engine for such purposes "[27] But though he continued to evolve new plans and modify old ones for the remaining thirty-five years of his life, he never produced plans for a "development engine "

In 1843 the solutions to his difficulties lay in mathematical (if not technical) developments between five and ninety-five years in the future, between George Boole's symbolic logic and Kurt Gödel's symbolic arithmetic.[28] He nevertheless continued to return to the problem from time to time In *The Exposition of 1851* he wrote

> I had frequently discussed with Mrs Somerville and my highly gifted friend the late Professor M'Cullagh of Dublin, the question whether it was possible that we should be able to treat algebraic formulae by means of machinery The result of many inquiries led to the conclusion that, if not really impossible, it was almost hopeless The first difficulty was that of representing an indefinite number in a machine of finite size This is not a fit place to enter into the detail of the means employed, further than to observe, that it was found possible to evade the difficulty by connecting *indefinite* number with the *infinite in time* instead of with the *infinite in space* The solution of this difficulty being found, and the discovery of another principle being made, namely — that *the nature of a function might be indicated by its position* — algebra, in all its most abstract forms, was placed completely within the reach of mechanism [29]

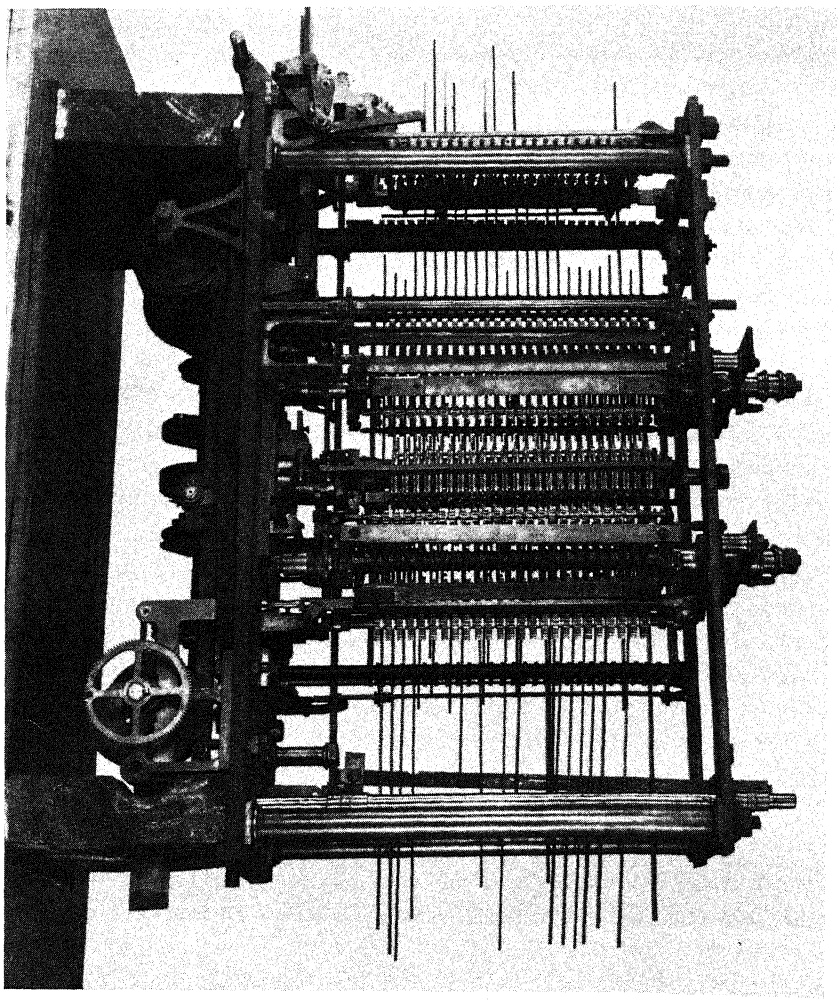
In this passage (whose "detail" is entered into in his autobiography) Babbage seems to believe that to be able to express an "indefinite" number, that is, a symbol standing for any number, one had to have the capacity to express an infinite number of significant figures This is not the case, and, anyway, neither his "solution" nor the other "principle" really deals with the problem posed by the numerical columns Since the creation of an "algebra machine" would have been so important a step in Babbage's approach to intellectual invention, it is difficult to avoid the conclusion that he never really succeeded in solving this problem

It is interesting (and significant) that Babbage mentioned discussing his difficulty with Mary Somerville, but not with Lady Lovelace Ada was not even aware of the nature of the problem, over which she repeatedly waved her hands (or wand, for she had taken to calling herself a fairy, despite Babbage's protests). While Menabrea more cau-

[27] Babbage's "Scribbling Books," vol 3, Microfiche D4, 3/9, 13 December 1837

[28] For illuminating discussions of machine coding, I am indebted to Garry J Tee, Department of Computer Science, University of Auckland, New Zealand However, I am responsible for any errors in the conclusions I have drawn Babbage did consider other number bases than the decimal, among them the binary, but he rejected them as too cumbersome or slow for his mechanism Electrical circuitry was not well enough developed until a number of years after this period, and even then he does not appear to have considered using it

[29] Charles Babbage, *The Exposition of 1851* (London Murray, 1851), p 184



(6) Model of the "mill" of the Analytical Engine, on which Babbage was working when he died (*Science Museum, London*).

tiously interpreted the machine's algebraic capacity as the calculation of the (numerical) coefficients of power or functional series, Ada makes more general claims in several of her Notes, unrestrained by Babbage In Note A she observes airily "It seems to us obvious, however, that where operations are so independent in their mode of acting it must be easy by means of a few simple provisions and additions in arranging the mechanism, to bring out a *double* set of results, viz — 1st, the *numerical magnitudes* which are the results of operations performed on *numerical data* 2ndly, the *symbolical results* to be attached to those numerical results, which symbolical results are not less the necessary and logical consequences of operations performed upon *symbolical data,* than are numerical results when the data are numerical" (*Memoir,* p 694)

It might be supposed that the method of "attaching" the symbolic results might be for some human programmer to have worked them out and arranged for them to be printed with the corresponding numerical results, but in Note E the claim is repeated with a variation that makes it clear that she had symbolic processing by machine in mind "The engine can arrange and combine its numerical quantities exactly as if they were *letters* or any other *general* symbols, and in fact it might bring out its results in algebraical *notation*, were provisions made accordingly It might develop three sets of results simultaneously, viz *symbolic* results (as already alluded to in Notes A and B), *numerical* results (its chief and primary object), and *algebraical* results in *literal* notation This latter, however, has not been deemed a necessary or desirable addition to its powers" (*Memoir,* p 713).

The distinction made here between "symbolic results" and "algebraical results in literal notation" implies that the former referred simply to the printing of formulae worked out by human "analysts" and "attached" to the numerical results When we turn to Note B to confirm this supposition, however, we find instead another type of confusion reigns Here Ada makes the claim for the algebraic capability of the engine with the aid of a diagram in which circles appear at the tops of the representations of the columns of stored numbers (In the actual plans, an extra disk at the top of each column would carry the sign of the number below, in the form of an even or odd digit.) She says. "Each circle at the top is intended to contain the algebraic sign plus or minus, according as the number represented on the column below is positive or negative In a similar manner any other purely *symbolical* results of algebraic processes might be made to

appear in these circles In Note A the practicability of developing *symbolical* with no less ease than *numerical* results has been touched on" (*Memoir*, p. 702) Touched on but not explained In the extract above, moreover, Ada seems to be succumbing to a curious confusion between the engine as planned and its representation in her diagram Although anything at all may be written with equal ease in circles on a diagram, it is more difficult to produce some things by mechanical means than others This kind of confusion is particularly tempting when the mechanism exists in the form of drawings only, and one the Menabrea, too, occasionally fell victim to

It was a trap that proved particularly difficult for Ada to avoid Her turn of mind, revealed in so much of her correspondence and other writing, was essentially intuitive and mystical Against these propensities, encouraged by her mother, Babbage fitfully fought hard It was the formal beauty and surprising, seemingly magical results of mathematical processes and reasoning which entranced her, yet it was actually a subject for which she had little natural talent, and one whose techniques, despite periods of hard work, continued to elude her Thus, she was never able to turn her probing questions and picturesque conceits into ingenious and fruitful solutions

It is one thing to speculate that some wonderful accomplishment might be possible, but, without a firm grasp of the subject matter, she was not only unable to suggest how it might be achieved, but unable to see that such an explanation was necessary The same prophetic vagueness with which she claimed that the Analytical Engine could easily be arranged to do algebra is equally evident in her notion that it could be programmed to compose music (*Memoir*, p 694)

VI

Ada was well aware of her technical deficiencies and was invariably timid and tentative with Babbage in these matters A paragraph in a letter of 14 August reveals this clearly, as well as the fact that Babbage's supervision of the Notes was so close that only one trivial footnote in the published version had been inserted without his previous approval: "I have ventured inserting into one passage of Note G a small Foot-Note, which I am not sure is *quite tenable* I say in it that the engine is remarkably well adapted to include the whole *Calculus of Finite Differences* & I allude to the computation of the *Bernoullian*

Numbers by means of the Differences of Nothing, as a beautiful example of its processes I hope it *is* correctly the case "[30]

Her letters also effectively refute Babbage's autobiographical statement that he had worked out the example of the Bernoulli numbers "to save Lady Lovelace the trouble" — an unlikely assertion since a number of them proclaim the time and trouble she was taking over this "illustration " Her decision to include it was announced in the following fashion· "It appears to me that I am working up the Notes with much success, & that even if the book be delayed in its publication, a week or two in consequence, it will be worth Mr. Taylor's while to wait I will have it *well* & *fully* done; or not at all I want to put in something about Bernoulli's numbers, in one of my Notes, as an example of how an implicit function may be worked out by the engine, without having been worked out by human head & hands first. Give me the necessary data & formulae "[31]

There is no sign at all in the surviving correspondence on either side that she ever sent his calculations back to him for correction Her labor over this example seems to have been expended in preparing the chart (which she called a "Table & diagram") that accompanied her discussion of it, and constituted the nearest approach to a computer program for a hundred years The general form of this was similar to Babbage's other programs, but Ada added embellishments and improvements. "Think of my horror then at just discovering that the Table & diagram (over which I have been spending infinite patience & pains) are seriously *wrong*, in one or two points I have done them however in a beautiful manner, much improved upon our *first* edition of the Table & diagram" (Add Mss. 37,192, f. 401)

The experience of working with a man of Babbage's calibre, on terms which friendship, and her rank and sex, made appear almost like equality, was heady to the point of intoxication It was also exhausting and nerve-wracking, pursued in the face of nagging illnesses It fed both a belief in her own abilities and an irritation with her colleague's more casual attitude. She went from a humble desire to serve him to a view of the division of labor between them in which she was executive and supervisor, he technician and informant. "I hope another year will

[30] Ada (Byron) Lovelace to Charles Babbage, 14 August 1843, Add Mss 37,192, f 422 The "Differences of Nothing' refers to the successive differences of the first terms of the series 0^n, 1^n, 2^n, etc , where n is a positive whole number In her footnote, and in this letter, Ada is vague about how she proposed to use these numbers

[31] Ada (Byron) Lovelace to Charles Babbage, Add Mss 37,192, f 362 This letter is incorrectly dated 10 July in Babbage's hand Several letters written earlier show she was already at work on this example

make me *really* something of an *Analyst* The more I study, the more irresistible do I feel my genius for it to be I do *not* believe that my father was (or ever could have been) such a *Poet* as *I shall* be an *Analyst* (& Metaphysician); for with me the two go together indissolubly" (Add Mss 37,197, f 407) Her writing ability and her transcendent mind, she wrote her mother, must make him value her services, her position, and her superior habits of organization qualified her to be his "Whipper-in."[32] She scolded him for altering her sentences and mislaying her papers "I wish you were as accurate, & as much to be relied on, as I am myself You might often *save* me much trouble, if you were; whereas you in reality *add* to my trouble not unfrequently By the way, I hope you do not take upon yourself to alter my corrections you have made a pretty mess & confusion in one or two places (which I will show you sometime), where you have ventured to *insert* or *alter* a phrase or word, & have utterly muddled the sense" (1 August 1843, Add Mss 37,192, f 414) A clash between Ada and Babbage was bound to come, but, when it did, it was not over her imperiousness but his

There was one point on which Babbage must have found Ada's use of the disingenuous disclaimer less pleasing and less useful than her exaggerated claims for his engine's powers The "philosophy" of Note A had also included the following· "Respecting the circumstances which have interfered with the actual completion of either invention, we offer no opinion, and in fact are not possessed of the data for doing so, had we the inclination" (*Memoir*, p 699) This declaration was Ada's way of distancing herself from Babbage's dispute with the government, and establishing a separate and disinterested position for herself and her future writing To her mother she explained "I declared at once to Babbage that no power should induce me to lend myself to any of his quarrels, or to become in any way his *organ* "[33] She was no longer "subservient to some of *your* purposes & plans "

Babbage immediately set about to remedy any absence of opinion among readers by composing his own statement on the point, to be included (anonymously) with Ada's publication He was anxious that it should not seem to emanate from himself When the editor of *Taylor's Scientific Memoirs* considered it too polemical to be included, rather than have it published separately, Babbage urged Ada to

[32] Ada (Byron) Lovelace to Lady Byron, 15 August 1843, L-B no 42, f 85 A "Whipper-in" was a person charged with controlling the dog-pack during a hunt

[33] Ada (Byron) Lovelace to Lady Byron, 8 August 1843, L-B no 42, f 73

withdraw her paper at the last minute [34] He was astonished and dismayed to receive an indignant refusal

Although Babbage had not initiated the translation, the preceding weeks and months had taken a heavy toll of his time and attention, diverted from work on his drawings He had been willing enough to comply with her stream of requests, however high-handedly made, for papers, books, meetings, explanations. Yet, despite the commands to supply her with materials, the summonses to her town house, the orders to take charge of this or that detail, to run errands to the printers, to stop meddling in her sentences, it had not occurred to him that she considered the paper her own property Now she sent him a demanding list of conditions that she wished to govern their future work together, she asked him to place himself and his invention in her hands:

> Firstly I want to know whether if I continue to work *on* & *about* your own great subject you will undertake to abide wholly by the judgment of myself (or of any persons whom you may *now* please to name as referees, whenever we may differ), on all *practical* matters relating to *whatever can involve relations with any fellow-creature or fellow creatures*
>
> Secondly Can you undertake to give your mind *wholly* & *individually* [*sic*], as a primary object that no engagement is to interfere with, to the consideration of all those matters in which I shall at times require your intellectual *assistance* & *supervision* & can you promise not to *slur* & *hurry* things over, or to mislay, & allow confusion & mistakes to enter into documents, &c?
>
> Thirdly If I am able to lay before you in the course of a year or two, explicit & honorable propositions for *executing your engine* (such as are approved by persons whom you may *now* name to be referred to for their approbation), could there be any chance of your allowing myself & such parties to conduct the business for you, your own *undivided* energies being devoted to the execution of the work, & all other matters being arranged for you on terms which your *own* friends should approve [35]

At last he understood. He refused all her conditions in such flattering terms that she was at first under the impression that he had accepted. The quarrel was patched up, but never again did he risk collaboration with his "dear and much admired Interpreter "[36]

It has often been deplored that Babbage's work had little or no influence on the development of the modern computer, and, in particular, that Lady Lovelace's "clear description" was not used or referred to in the process The immense reverence for Babbage's awesome abilities has seemed to require acceptance of his assessment of her

[34] Charles Babbage to Ada (Byron) Lovelace, L-B no 168, f 42, Ada (Byron) Lovelace to Charles Babbage, Add Mss 37,192, f 422

[35] Ada (Byron) Lovelace to Charles Babbage, 14 August 1843, Add Mss 37,192, f 422

[36] Charles Babbage to Ada (Byron) Lovelace, 9 September 1843, L-B no 168

Notes An examınatıon of the document ıtself, of the context ın whıch ıt was wrıtten, and of contemporary correspondence, ındıcates that the Notes actually presented a pıcture of the Analytıcal Engıne both mıs-leadıng and ınconsıstent The descrıptıon was dıstorted by the ınventor's ıdeology ın economıcs, theology, and mathematıcs, by hıs polıtıcal purposes, by the author's aspıratıons, by the ınadequacıes of her traınıng and understandıng, and by the socıal relatıon between them Such ınfluences were bound to lessen the paper's usefulness as a blueprınt for a twentıeth-century, war-motıvated technologıcal development Strangely enough, ıt was the ınventor's vısıon of the engıne's capacıty to dısplace labor, and the author's mystıcal fervor whıch have proved truly prophetıc of the computer's posıtıon and pres-tıge ın our own socıety

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David B Wilson

A PHYSICIST'S ALTERNATIVE TO MATERIALISM: THE RELIGIOUS THOUGHT OF GEORGE GABRIEL STOKES*

THERE WERE FEW MATERIALISTS IN VICTORIAN BRITAIN, BUT MATERIALISM nevertheless seemed a considerable threat to late Victorian Christianity John Tyndall, speaking in 1874 from that pulpit of Victorian science, the presidency of the British Association for the Advancement of Science, gave an expanded and more controversial account of the "scientific materialism" he had advocated to the association six years earlier [1] He supported his position with Charles Darwin's theory of evolution and the doctrine of the conservation of energy Though even Tyndall stopped short of a totally materialistic explanation of the "why" of life, niceties of distinction were easily lost in a time of militant agnosticism and growing emphasis on naturalistic explanations in science [2] Even if noticed, Tyndall's nod toward the "immovable basis of the religious sentiment in the nature of man"[3] could offer little comfort to the traditional Christian, for it reduced the richness of Christianity to mere feeling in an essentially material world Moreover, the Christian, living in a society in which urban masses avoided churches in large numbers and in which the privileged position of clergymen was being challenged by an ever-strengthening

* I am grateful to the Syndics of the Cambridge University Library for permission to publish passages from manuscript material, especially from the Stokes Collection, Add Mss 7656 For a description of that collection, see D B Wilson, *Catalogue of the Manuscript Collections of Sir George Gabriel Stokes and Sir William Thomson, Baron Kelvin of Largs in Cambridge University Library* (Cambridge Cambridge University Library Press, 1976) Research for the paper was assisted by the Mechanical Engineering Department, Iowa State University

[1] 'Scientific Materialism" is the title Tyndall gave to the reprint of his 1868 address in his *Fragments of Science*, 2 vols (New York P F Collier & Son, 1902), II, 82-98 His more famous address of 1874 was reprinted simply as "The Belfast Address" in *Fragments of Science*, II, 145-214 Untitled, the two addresses are in *Report of the British Association for the Advancement of Science* (1868), part 2, pp 1-6, and (1874), pp lxvi-xcvii

[2] T H Huxley, for example, expected one of his essays, in which he carefully distinguished his position from materialism, to be attacked as "gross and brutal materialism" (Huxley, "On the Physical Basis of Life,' in *Method and Results* [London Macmillan, 1894], p 154 The essay dates from 1868) In a note added to the essay in 1892, Huxley wrote that "I cannot say I have ever had to complain of lack of hostile criticism, but the preceding essay has come in for more than its fair share of that commodity" (p 165)

[3] Tyndall, *Report of the British Association* (1874), p xcv

community of scientists, could not help but feel that any move away from traditional Christianity toward agnosticism or materialism was only being hastened by social realities The late Victorian religious establishment had to worry about evangelizing the working classes and defending its own place in society, while also contending with an outburst of new ideas, none more unwelcome than Tyndall's [4]

A highly prominent scientist, George Gabriel Stokes was, in addition, an outspoken member of that religious establishment, naturally concerned with evangelizing non-Christians and answering questions posed by modern science and scholarship Stokes (1819-1903) graduated from Cambridge University in 1841 as senior wrangler in the mathematical tripos and during the next decade or so published research in hydrodynamics and optics that established him as one of the three or four leading physicists of his generation His work in hydrodynamics was credited with making that discipline into "an ordered mathematical and experimental theory "[5] In optics he investigated problems facing the recently established wave theory of light, and his discovery of fluorescence earned him the Rumford Medal of the Royal Society of London in 1852. He was elected Lucasian professor of mathematics at Cambridge in 1849, holding the chair until his death, and in 1851 gained membership in the Royal Society, which he served as secretary for three decades and as president from 1885 to 1890 In 1898 Lord Kelvin declared that "Sir George Stokes has in my opinion higher claims for the award of the Helmholtz Medal [of the Royal Academy of Sciences, Berlin] than any other physicist or mathematical physicist who has given his work to the world in the English language "[6] Conservative in religion, Stokes maintained extensive cor-

[4] For discussions of the variety of religious controversy in Victorian Britain, see Maurice Mandelbaum, *History, Man, & Reason A Study in Nineteenth-Century Thought* (Baltimore Johns Hopkins University Press, 1971), pp 20-37, Owen Chadwick, *The Victorian Church*, 2 vols (New York Oxford University Press, 1966-1970), Bernard M G Reardon, *From Coleridge to Gore A Century of Religious Thought in Britain* (London Longman, 1971), G Kitson Clark, *The Making of Victorian England* (London Methuen, 1965), J W Burrow, "Faith, Doubt, and Unbelief, in Laurence Lerner, ed , *The Context of English Literature The Victorians* (New York Holmes and Meier, 1978), pp 153-173, Josef L Altholz, "The Warfare of Conscience with Theology," in his edition of *The Mind and Art of Victorian England* (Minneapolis University of Minnesota Press, 1976), pp 58-77, Martin J S Rudwick, "Charles Darwin in London The Integration of Public and Private Science,' *Isis*, 73 (1982), 186-206, Jack Morrell and Arnold Thackray, *Gentlemen of Science Early Years of the British Association for the Advancement of Science* (Oxford Clarendon Press, 1981), especially pp 224-245, Frank M Turner, 'John Tyndall and Victorian Scientific Naturalism," in W H Brock, et al , eds , *John Tyndall Essays on a Natural Philosopher* (Dublin Royal Dublin Society, 1981), pp 169-180, and K S Inglis, *Churches and the Working Classes in Victorian England* (London Routledge and Kegan Paul, 1963)

[5] Joseph Larmor, "Stokes, Sir George Gabriel, first baronet (1819-1903)," *Dictionary of National Biography*

[6] Lord Kelvin to Arthur Julius Georg Friedrich von Auwers, 22 October 1898, Glasgow University Library, Kelvin Papers, LB5/168 Stokes received the Helmholtz Medal in 1901 I am grateful to the Court of Glasgow University for permission to publish this letter

respondence with clergymen and frequently spoke publicly on religious topics As its president, he often addressed the Victoria Institute, a society founded in the 1860s to combat the influence of *Essays and Reviews* and the *Origin of Species* He was several times invited to address annual meetings of Church Congresses As a well-known religious scientist, he was selected in the 1880s to be the first Burnett lecturer in Aberdeen and in the 1890s to deliver the Gifford Lectures in Edinburgh Unexceptional in the 1840s, his religious views were exceptional by the 1890s.[7]

Victorian scientists' religious thought is becoming much better understood Long gone is the time when one could regard Victorian scientists simply as non-religious opponents of religion Gone also is the time when one could be content merely with pointing out that many scientists were Christians There now exist numerous studies exploring the nature and influence of scientists' religious thought One thinks of Robert M. Young's discussion of the "common context" of biological, social, and theological discourse, or of Michael Ruse's division of scientists into liberal, centrist, and conservative camps, or of Frank M Turner's group residing "between science and religion "[8] There are also studies of such scientists as Darwin, Sir Charles Lyell, Michael Faraday, P. G Tait, Lord Kelvin, and James Clerk Maxwell [9] However, scholars have paid more attention to biologists and geologists than to physical scientists and more to late Victorian doubters than to

[7] For biographical material on Stokes, see Lord Rayleigh, "Sir George Gabriel Stokes, Bart , 1819-1903," *Proceedings of the Royal Society of London*, 75 (1905), 199-216, Lord Kelvin, "The Scientific Work of Sir George Stokes," in Kelvin, *Mathematical and Physical Papers*, 6 vols (Cambridge Cambridge University Press, 1882-1911), VI, 339-344, Joseph Larmor, ed , *Memoir and Scientific Correspondence of the Late Sir George Gabriel Stokes*, 2 vols (Cambridge Cambridge University Press, 1907), and E M Parkinson, "Stokes, George Gabriel," in *Dictionary of Scientific Biography*, vol 13 (New York Charles Scribner's Sons, 1976), 74-79

[8] Robert M Young, "Malthus and the Evolutionists The Common Context of Biological and Social Theory," *Past and Present*, no 43 (1969), 109-145, Michael Ruse, "The Relationship between Science and Religion in Britain 1830-1870," *Church History*, 44 (1975), 505-522, and Frank M Turner, *Between Science and Religion The Reaction to Scientific Naturalism in Late Victorian England* (New Haven Yale University Press, 1974)

[9] See, for example, Maurice Mandelbaum, "Darwin's Religious Views," *Journal of the History of Ideas*, 19 (1958), 363-378, Dov Ospovat, *The Development of Darwin's Theory Natural History, Natural Theology, and Natural Selection, 1838-1859* (Cambridge Cambridge University Press, 1981), Martin J S Rudwick, "The Strategy of Lyell's *Principles of Geology*," *Isis*, 61 (1970), 4-33, Michael Bartholomew, "Lyell and Evolution An Account of Lyell's Response to the Idea of an Evolutionary Ancestry for Man," *British Journal for the History of Science*, 6 (1973), 261-303, David Gooding, "Empiricism in Practice Teleology, Economy, and Observation in Faraday's Physics," *Isis*, 73 (1982), 46-67, P M Heimann, "The *Unseen Universe* Physics and the Philosophy of Nature in Victorian Britain," *British Journal for the History of Science*, 6 (1972), 73-79, D B Wilson, "Kelvin's Scientific Realism The Theological Context," *The Philosophical Journal*, 11 (1974), 41-60, Joe D Burchfield, *Lord Kelvin and the Age of the Earth* (New York Science History Publications, 1975), pp 47-50, Crosbie Smith, "Natural Philosophy and Thermodynamics William Thomson and 'The Dynamical Theory of Heat,' " *British Journal for the History of Science*, 9 (1976), 293-319, and P M Heimann, "Molecular Forces, Statistical Representation and Maxwell's Demon," *Studies in History and Philosophy of Science*, 1 (1970), 189-211

their religious colleagues In fact, Stokes, the most public religious scientist of that era, has received only brief notice By focusing on Stokes's religious thought, therefore, this paper deals with relatively neglected aspects of Victorian scientists' religious views and their place within the nineteenth-century framework of issues

Previous discussions, though brief, have at least signaled Stokes's significance. He has been noted as an "exhibit" which beleagered Victorian Christians could use in their cause (Chadwick, *The Victorian Church*, II, 6) He has been pointed to as an exponent of "dualistic idealism" in contrast to the agnosticism and materialism of some of his contemporaries [10] His opposition to the doctrine of eternal torment has led him to be described as the main scientific proponent of the doctrine of conditional immortality [11] Going beyond such comments, this paper examines the context and content of Stokes's religious thought The first section describes the shaping of his overall religious viewpoint, the next two concentrate on the areas attracting most of his attention — espousal of the doctrine of conditional immortality and opposition to an extreme view of biological evolution Though both these areas involved the rejection of materialism, it is the paper's final section which examines Stokes's concept of "directionism," attempting to show how the various aspects of his thought contributed to this his specific alternative to materialism

I

Stokes's religious views combined Evangelical Christianity both with some of William Paley's ideas and those of certain critics of Paley at Cambridge. The Evangelical movement was the vital element in early nineteenth-century British religion Crossing denominational lines, it swelled membership in Anglican and dissenting churches Unlike high-church Anglicanism, Evangelical Anglicanism leaned not toward Catholicism and the upper classes, but toward dissent and the lower classes Unlike high-church or liberal Anglicanism, it was noted for neither sophisticated theological argument nor a historical and

[10] Noel G Coley and Gerrylynn K Roberts, "Scientists and the Spiritual World," in *Science and Metaphysics in Victorian Britain* (Milton Keynes The Open University Press, 1981), pp 42-44

[11] Geoffrey Rowell, *Hell and the Victorians A Study of Nineteenth-Century Theological Controversies Concerning Eternal Punishment and the Future Life* (Oxford Clarendon Press, 1974), p 204

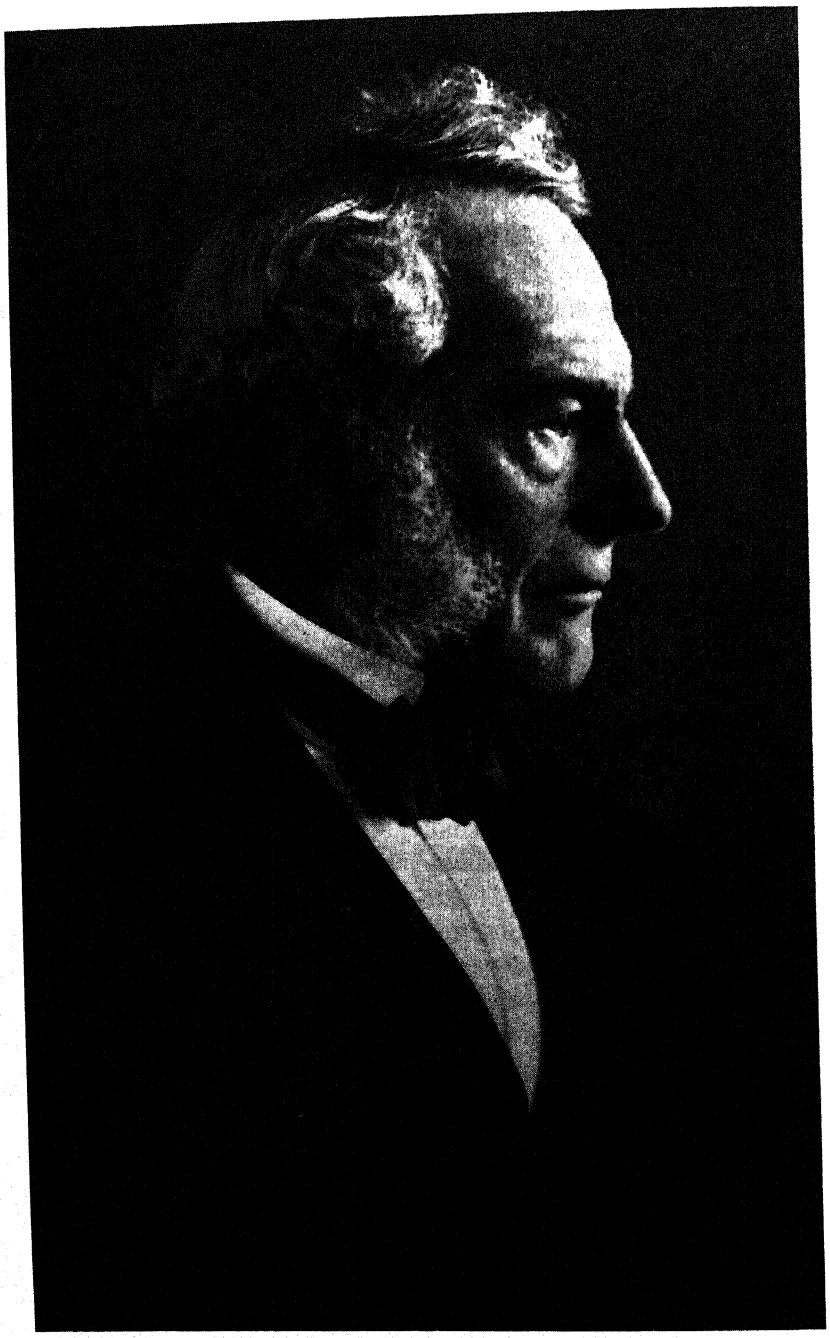
scholarly approach to the Bible Rather, Evangelicals emphasized emotional attachment to Christianity, earnestness of religious purpose, close attention to Scripture, and deep concern for the doctrine of Atonement with the attendant threat of eternal punishment for the unsaved To save those so threatened, they enthusiastically evangelized for their version of Christianity, founding, for example, the Church Missionary Society in 1799 and the British and Foreign Bible Society in 1804 Two centers of Evangelical Anglicanism were Clapham, where the Clapham Sect resided, and Cambridge University At Cambridge, Evangelicals occupied important university positions and were led by Charles Simeon, a 1783 Cambridge graduate, vicar of Holy Trinity Church in Cambridge from 1783 until his death in 1836, and one of the founders of the Church Missionary Society In 1856 at least 247 undergraduates regarded themselves as Evangelicals.[12]

Prevailing religious views at Cambridge, however, had more to do with William Paley than with Evangelicalism. All three of his chief works *(Natural Theology, Evidences of Christianity,* and *Moral Philosophy)* received wide attention at Cambridge, the latter two being required for Cambridge examinations

Paley's mutually reinforcing *Natural Theology* and *Evidences* rejected David Hume's arguments against the design argument and the reality of miracles Paley discussed numerous examples of design in a watch-like universe and confidently proclaimed the existence of a one, good, designing God Furthermore, "once believe that there is a God, and miracles are not incredible " Miracles constituted the primary evidence for the truth of Christianity. Where Hume saw unreliable testimony for the reality of miracles, Paley spoke of the "probity and good sense" of the witnesses to Christ's miracles and of the hardships they endured as they sought to spread His message [13] Their willingness to suffer for what they preached helped demonstrate the truth of Christianity "Auxiliary evidences for Christianity," according to Paley, included Biblical prophecy, the high morality of the gospels, the candor of the writers of the New Testament, the originality of Christ's character, and the agreement of the four gospels on the nature of

[12] Chadwick, *The Victorian Church*, I, 447 See D A Winstanley, *Early Victorian Cambridge* (Cambridge Cambridge University Press, 1955), pp 18-28, and Standish Meacham, *Lord Bishop The Life of Samuel Wilberforce, 1805-1873* (Cambridge, Massachusetts Harvard University Press, 1970), pp 12-13, where he notes Wilberforce as an exception to the Clapham pattern of sending their sons to Cambridge

[13] William Paley, *A View of the Evidences of Christianity* in *The Works of William Paley* (London Jennings and Chaplin, 1834), p 6



George Gabriel Stokes about 1892, age about 73. From G. G. Stokes, *Mathematical and Physical Papers* (Cambridge: Cambridge University Press, 1905), V, frontispiece. "Copyright from life by Mrs. F. W. H. Myers, 1892."

Christ's character. As one well-known Cambridge graduate of the 1820s summarized his and doubtlessly many others' reaction to Paley's books: "I am convinced that I could have written out the whole of the *Evidences* with perfect correctness, but not of course in the clear language of Paley The logic of this book and as I may add of his *Natural Theology* gave me as much delight as did Euclid "[14]

Paley's *Moral Philosophy*, however, though a required part of the examination for a pass degree, did not give quite the same "delight" as his other books Paley presented a utilitarian morality later summarized by Leslie Stephen "Christ came to tell us that we should go to hell if our actions did not tend to promote the greatest happiness of the greatest number."[15] During the 1830s, Paley's ideas were challenged by Adam Sedgwick and William Whewell, both of whom asserted that morality rested on a divinely implanted, innate sense of right and wrong. Whewell thought that Man could recognize his innate conscience either with or without the aid of revelation Citing Romans for support, he wrote that all men "have within them a voice which accuses and condemns them God has established in their bosoms a power which tries, judges, punishes and rewards their most secret actions "[16]

One could hardly avoid encountering the views of Sedgwick and Whewell in early Victorian Cambridge. Sedgwick's *Discourse on the Studies of the University* appeared first in 1833 and reached its fourth edition in 1835 [17] Whewell, who held the professorship of moral philosophy from 1838 to 1855, published many works on moral philosophy in the 1830s and 1840s, including *On the Foundations of Morals*, "four sermons preached before the University of Cambridge in November 1837." In November 1837 Stokes was a new Cambridge undergraduate, and the first four University sermons he attended were these by Whewell attacking Paley's moral philosophy [18]

Stokes came to the ideas of Paley and Whewell from his youthful background in Evangelical Christianity Stokes's father was the rector

[14] Charles Darwin, *The Autobiography of Charles Darwin, 1809-1882*, ed Nora Barlow (New York W W Norton, 1969), p 59

[15] Leslie Stephen, *History of English Thought in the Eighteenth Century*, 2 vols (New York Harcourt, Brace & World, 1962), I, 353 Quoted with approval in M L Clarke, *Paley Evidences for the Man* (London Society for Promoting Christian Knowledge, 1974), p 72

[16] William Whewell, *On the Foundations of Morals*, four sermons preached before the University of Cambridge in November 1837 (Cambridge and London, n d), p 19

[17] Adam Sedgwick, *A Discourse on the Studies of the University*, 4th ed (Cambridge J Smith for J and J J Deighton, 1835)

[18] Stokes s notes on the sermons are in the Stokes Collection, PA36

of Skreen, County Sligo, and Stokes's three older brothers also became Anglican clergymen Commenting on Stokes's childhood, the vicar of the church in Cambridge where Stokes had long been church warden declared

> Though he was never narrow in his faith and religious sympathies, he always held fast by the simple evangelical truths he learned from his father, the Protestant rector of Skreen, in the county of Sligo
>
> He several times gave me interesting details of his early years In his case certainly "the child was father of the man", for he soon became deeply thoughtful about religious matters, whilst he quickly developed indications of his remarkable mental powers
>
> "I recollect," he once wrote, "when I was a little child being so horrified at the idea of endless torments that I wished there was no God and no future state, lest I should fall into them No doubt (he continued) all children are naughty more or less, but I don't think I was what would be called a naughty child as children go, perhaps rather the reverse Perhaps my mind being naturally of a mathematical turn, I took in the idea of infinite duration more readily than most children would have done "[19]

In adulthood, Stokes agreed to be vice-president of the Evangelical British and Foreign Bible Society in 1891 and took part in its meetings.[20] He was active in the affairs of the Church Missionary Society and wrote on doctrinal matters relevant to missionary work.[21] Perhaps even his supreme conscientiousness in pursuing his duties as secretary of the Royal Society and in corresponding with those seeking advice reflected an Evangelical seriousness of purpose [22] Said his vicar· "It was the fact that Sir George's character rested upon his religious faith, that we of this parish are witnesses of more than others "[23]

Stokes's writings on religion reflect an Evangelical approach Though he disagreed with the usual Evangelical view of eternal punishment, for example, he did so in typical Evangelical fashion, through close argument from Scripture Indeed, despite his interest in Paley and Whewell, the foundation of his religious views was the Bible, not philosophical or theological deliberations That was why he found

[19] H P Stokes, "Reminiscences of Sir George Stokes," *Cambridge Chronicle* (13 February 1903) The quotation from Stokes is in G G Stokes, *Conditional Immortality A Help to Sceptics* (London James Nisbet & Co , 1897), pp 28-29

[20] H P Stokes, "Reminiscences of Sir George Stokes," reports on remarks made by Stokes to a meeting of the British and Foreign Bible Society in Oxford in 1897

[21] For example, he wrote that polygamists converted to Christianity should be allowed to remain polygamists G G Stokes, "On Polygamy in Connection with Christian Missions," reprint from the *Churchman* contained in the Cambridge University Library

[22] Michael Foster, Stokes's fellow secretary at the Royal Society, wrote, "It has been painful to see how his energy has been wasted in this way" (Foster to Lady Rayleigh, 1884, in Robert John Strutt, Fourth Baron Rayleigh, *Life of John William Strutt, Third Baron Rayleigh* [Madison University of Wisconsin Press, 1968], p 168)

[23] H P Stokes, "Reminiscences of Sir George Stokes "

his twenty Gifford Lectures on natural theology so onerous a task Forbidden by Lord Gifford's will to bring revealed religion into the discussion, Stokes apologized to his audience for what he regarded as the inadequacies of his lectures In his own life, he stated, "I have gone on the basis of accepting a supernatural revelation, more especially on that of accepting the resurrection of Jesus of Nazareth as a supernatural historical fact I have never written on, and I may add I have never specially studied, natural theology or moral philosophy "[24] Though Stokes's most fundamental views thus relied more on an intimate knowledge of Scripture than on philosophical-theological contemplation, nevertheless, his thought did bear the imprint of Paley and Whewell to a significant extent

As had Paley, for example, Stokes declared: "Admit the existence of a God, of a personal God, and the possibility of miracle follows at once" (Stokes, *Natural Theology*, I, 24) He also agreed with Paley in noting the importance of the honesty of the narrative and the character of Jesus as evidence of the Bible's truthfulness At the least, the New Testament could be regarded "as honestly-written narratives, not exempt from such errors in small details as an ordinary historian, however honest and painstaking, might fall into" (Stokes, *Conditional Immortality*, p 81) The narrative described a man of high character, and such a man could not commit the blasphemy of falsely claiming to be the Son of God (pp 63-65) But as well as an *Evidences* concern for the "head," Stokes displayed an Evangelical concern for the "heart"

> The admission of the resurrection of Jesus Christ, if regarded as a dry isolated fact, would I think be of little or no value It seems to have been God's *design* that it should *not* be so regarded We read, "God raised him from the dead and showed him openly, *not unto all the people*, but unto witnesses chosen afore of God " Were admission of the fact of the resurrection the one important thing, the obvious way (if one may so speak without irreverence) to secure it would have been to have shown Him openly The evidence for the resurrection of Jesus Christ is never to be separated from a consideration of the character and teaching and works of Jesus Christ The head and heart must go together [25]

As Stokes said, he had written little on natural theology before his first set of Gifford Lectures in 1891 Nowhere, not even in the Gifford Lectures themselves, did he examine the general philosophical underpinning of the design argument or attempt, for example, to answer David Hume's specific objections to it He clearly did accept and use the argument, however, and left no doubt that he agreed with

[24] G G Stokes, *Natural Theology The Gifford Lectures*, 2 vols (London Adam and Charles Black, 1891-1893), I, 270 See also I, 187, and Larmor, ed , *Memoir and Scientific Correspondence*, I, 17

[25] Stokes to A H Tabrum, 5 October 1899, in Larmor, ed , *Memoir and Scientific Correspondence*, I, 80 See Stokes, *Natural Theology*, II, 215-222, where he discusses Christ's character based on the gospels "regarded as simple history "

Paley "I regard [design] much in the same way that was mentioned long ago by Paley in his *Natural Theology*, when he spoke of the difference between a man's impression in picking up a stone on a common and in picking up a watch "[26]

Whewell was, likewise, Stokes's main authority for moral philosophy In his first series of Gifford Lectures, he rejected utilitarian morality, which only had a "very limited application," in favor of the "school of moralists [who] hold that we have an innate consciousness of right and wrong" (Stokes, *Natural Theology*, I, 227-228). Like Whewell, he said that although the mental faculties involved in moral philosophy differed from those employed in geometry and physics, they still were "natural powers of the mind" (I, 224). Like Whewell, Stokes compared the "first principles of right and wrong" to the axioms of geometry and argued that, though feelings of right and wrong were innate to the mind, they may require "the exercise of some thought to bring them to the surface" (I, 228-229). Hence, though Stokes did not adopt Whewell's Kantian-like theory of knowledge for science, he clearly did do so for moral philosophy

Indeed, it was in his discussion of Whewellian moral philosophy that Stokes perhaps best summed up his own set of concerns and viewpoints

> To me it seems to be the simplest to suppose that man's mental powers, as well as his bodily frame, were designed to be what they are How that design was carried out we have no means of knowing, and it does not concern us to inquire, but, assuming that it was so, I see no difficulty in supposing that man's innate sense of right and wrong was as much impressed upon him, as little the creation of his own will, as his bodily frame If that be so, we may even look on this innate sense of right and wrong as the will of God written upon the heart, and some rules of guidance may be obtained even without having recourse to a supernatural revelation
>
> (Stokes, *Natural Theology*, I, 231)

Here there is not only the implication, spelled out by Stokes elsewhere, that such conclusions dovetail with a Scripture viewed in the manner of *Evidences* and Evangelicalism, but also the focusing of Paleyean natural theology and Whewellian moral philosophy on that central religious issue — the nature of Man It was this issue which dominated Stokes's criticism both of the Christian doctrine of eternal torment and the Darwinian theory of biological evolution.

[26] Stokes's remarks made in the discussion following his address, "On the Bearings of the Study of Natural Science, and of the Contemplation of the Discoveries to which that Study Leads, on Our Religious Ideas," *Journal of the Transactions of the Victoria Institute*, 14 (1880), 227-248 The quotation is on p 247

II

The young George Stokes was not the only one unhappy with the doctrine of eternal punishment At times, it must have seemed likely to become a source of eternal controversy In 1853 F D Maurice reinterpreted the doctrine so that "eternal" did not mean a period of time [27] He was dismissed from his professorship at King's College, London In the 1860s great and official Church consternation greeted criticism of the doctrine in *Essays and Reviews* and by Bishop Colenso of Natal in connection with his missionary work The agnostic Charles Darwin, in his *Autobiography*, written around 1880, called it "a damnable doctrine" and could "hardly see how anyone ought to wish Christianity to be true" (Darwin, *Autobiography*, p 87) His Christian wife's response was no less hard on the doctrine itself. "Nothing can be said too severe upon the doctrine of everlasting punishment for disbelief — but very few now [1882] wd. call that 'Christianity,' (tho' the words are there)" (p 87n) The urban masses, their tenuous link to organized religion already documented by the religious census of 1851, began hearing the militant atheism preached by the working-class Secular or Freethought Movement which was formed in the 1850s and peaked in the 1880s [28] "When Secularists named the Christian doctrines they found most objectionable, they were almost always those of Eternal Punishment, Hell, the Atonement, and Damnation for unbelievers" (Budd, "Loss of Faith," p 118)

Against this background, the movement for the doctrine of conditional immortality as a replacement for that of endless punishment began in the 1840s and was much discussed during the 1870s (Rowell, *Hell and the Victorians*, pp 180-207) Most widespread among Congregationalists and Evangelical Anglicans, the view reserved immortality for the saved, condemning the rest to extinction Though less cruel than eternal torment, extinction retained the sting absent from the "universalist" alternative that everyone would eventually be saved The doctrine was seen as befitting a kind God who nevertheless expected humans to behave themselves At first met only with reprobation, conditionalists succeeded well enough to contribute significantly to the well-known, overall changes in Victorian religious thought At the end of the century, "it is true that the doctrine of hell had not been

[27] F D Maurice, "Concluding Essay — On Eternal Life and Eternal Death,' in *Theological Essays*, introduction by E F Carpenter (London James Clarke, 1957)

[28] Susan Budd, "The Loss of Faith Reasons for Unbelief among Members of the Secular Movement in England, 1850-1950," *Past and Present*, no 36 (1967), 106-107

removed from the official theological confession of any denomination, but men were no longer deprived of office for teaching a tentative universalism or regarded with suspicion for espousing the doctrine of conditional immortality" (Rowell, *Hell and the Victorians*, p 212)

Stokes began his mature deliberations on eternal punishment in 1851, his daughter tells us, when he was thirty-two years old [29] He was possibly influenced by the book *Life in Christ* published in 1846 by Edward White, a Congregational minister who became the leading proponent of the doctrine of conditional immortality.[30] By the late 1860s, Stokes had fully accepted the doctrine,[31] and in the 1870s he was urging the position on others, including his nephew Reverend W H Askwith, P G Tait, William Walton, and T T Perowne [32] In 1877 he tried but failed to get the London Christian Evidence Society officially to adopt the doctrine of conditional immortality [33] In that decade he began what became an enormous correspondence with Edward White himself, and White quoted at length from one of Stokes's letters in the preface to his book's third edition in 1878 [34] In the early 1880s Stokes was caught up in a long correspondence on behalf of Walter Dening, a missionary to Japan for the Church Missionary Society who evidently had been preaching conditional immortality too vigorously. In connection with that controversy, Stokes published a pamphlet privately in 1882, which presented three missionaries' favorable reports on the doctrine that had been forwarded to Stokes by White [35] He wrote to the

[29] Lamor, ed , *Memoir and Scientific Correspondence*, I, 46

[30] Edward White, *Life in Christ Four Discoveries upon the Scripture Doctrine that Immortality is the Peculiar Privilege of the Regenerate* (London, 1846)

[31] Stokes, *Conditional Immortality*, p 19, and G G Stokes, "Is the Soul of Man by Its Nature Immortal?" a paper read at Sion College on 20 April 1893, p 138 I have used a reprint contained in the Cambridge University Library from a journal or magazine I have not identified

[32] Askwith, a Cambridge graduate of 1867 and a curate in Devon from 1867 to 1874, sharply rejected his uncle s views (Correspondence from Askwith to Stokes, beginning in 1872, is in the Stokes Collection) Tait, professor of natural philosophy at Edinburgh, was interested but not convinced, at least not in 1875 (Tait to Stokes, 6 March and 11 March 1875, Stokes Collection, T73 and T74) Walton, a high wrangler at Cambridge in the 1830s, agreed "I return to you by this post Constable s Treatise on Future Punishment The conclusion, at which he arrives, has been my conviction for many years' (Walton to Stokes, 26 June 1874, Stokes Collection, W100) Perowne, a Cambridge graduate of 1847 and archdeacon of Norwich from 1878 to 1910, disagreed "In his argument from Holy Scripture, Mr Constable appears to me completely to break down" (Perowne to Stokes, 30 July 1874, Stokes Collection, P230) On Constable, see note 40

[33] P Barker, secretary of the Christian Evidence Society, to Stokes, 18 May 1877, Stokes Collection, C391

[34] Edward White, *Life in Christ A Study of the Scripture Doctrine on the Nature of Man, the Object of the Divine Incarnation, and the Conditions of Human Immortality*, 3d ed (London Elliot Stock, 1878), p vii This is the third edition of White's book published in 1875, which White regarded as a different book, though with the same basic title, from the one published in 1846 Some 265 letters from White to Stokes are in the Stokes Collection

[35] G G Stokes, *Evidence of Missionaries as to the Practical Effect of Presenting Christianity to the Heathen in the Form Associated with the Doctrine of "Life in Christ,"* (Cambridge privately printed, 1882)

Church Missionary Society that "if this counsel or this work be of God, ye cannot overthrow it, lest haply ye be found even to fight against God Ye cannot indeed overthrow it; but how know you but that in the endeavour to stifle it by muzzling the evangelist sent out to the heathen you may be the occasion of preventing the salvation of many a soul for whom Christ died?"[36]

In the 1890s Stokes finally published his own formulations of the doctrine, reflecting views defined by Edward White and others whose works had flourished in the 1870s One of these was Reverend Henry Smith-Warleigh, whose correspondence with Stokes apparently began with his sending Stokes a copy of his *Hear the Church of England* (1872), which argued that the Church of England had actually rejected the doctrine of eternal punishment [37] Smith-Warleigh wrote Stokes that "the dogma of endless torments, inflicted by a God of beneficence, has been more fruitful than any other one cause of the growing infidelity and indifference of the myriads of our artizans and even of our educated countrymen "[38] Smith-Warleigh thought White and two others were the only ones in London doing useful teaching against the doctrine of eternal punishment.[39] The others were Reverend Samuel Minton and Reverend Henry Constable, with both of whom Stokes later corresponded.[40] Constable's *Future Punishment* was the book he sent others. Smith-Warleigh may have helped bring White and Stokes together [41] Their correspondence began in 1875 when White replaced Smith-Warleigh as Stokes's principal correspondent on conditional immortality

Without attempting a detailed analysis of the differing emphases and opinions contained in the body of literature produced by these men, we can at least identify their primary areas of agreement

[36] Stokes's copy of his letter to Mr Barton, 12 December 1881, Stokes Collection, B163 Relevant letters on the controversy are scattered through many parts of the Collection

[37] Henry Smith-Warleigh, *Hear the Church of England which Is Proved to Have Expelled from Her Articles the Dogma of Endless Torments* (London, 1872) Smith-Warleigh to Stokes, 29 June 1872 and 2 April 1873, Stokes Collection, W155 and W176 Smith-Warleigh, of Ashchurch Rectory in Gloucestershire, published other works, including *A Demonstration of the Extinction of Evil Persons and of Evil Things* (London E Stock, 1871), one copy of which was ordered by Stokes (Smith-Warleigh to Stokes, 29 June 1872, Stokes Collection, W155)

[38] Smith-Warleigh to Stokes, 29 June 1872, Stokes Collection, W155

[39] Smith-Warleigh to Stokes, 7 May 1873, Stokes Collection, W178

[40] Minton, an Oxford graduate of 1842, published *The Glory of Christ in the Creation and Reconciliation of All Things* (London, 1868), *The Way Ever-Lasting* (London Elliot Stock, 1869), and *The Harmony of Scripture on Future Punishment* (London, 1872) These works, "by my friend and fellow-labourer," were praised by White in the third edition of his *Life in Christ*, p v Constable, chaplain of the City of London Hospital for Diseases of the Chest, published *The Duration and Nature of Future Punishment* (London Longmans, Green, & Co , 1868) and *Hades, or the Intermediate State of Man* (London Elliot Stock, 1873)

[41] Smith-Warleigh to Stokes, 15 November 1875, Stokes Collection, W197

which Stokes later endorsed First, truth in these matters depended ultimately on the Bible. "This book rests the question of Immortality wholly on interpretation of Scripture," White wrote (*Life in Christ*, 3d ed , p iii) "One verse of the Bible on the nature of man, on the source of his life, on the meaning of his death, must outweigh a whole treatise of Plato, Aristotle, or Epicurus," Constable declared (*Hades*, p 8). Second, the doctrine of conditional immortality was verified by Scripture, whereas neither universalism nor the doctrine of eternal punishment was Third, the tripartite nature of Man was Biblical, the dual nature of Man was Platonic, and wrong. Fourth, related questions — for example, whether human beings were conscious, alive, and/or evangelized during the intermediate state between death and Judgment — were worth examining, even at length, but in the end were far less crucial than the question of immortality Hence, theirs was an intricate and exhaustive search of Scripture for truth — a search driven by challenges to Christianity at home and abroad and from all levels of society

The same search, with its conceptual and social motivations, carried over into Stokes's writings of the 1890s He presented his views in three publications besides the Gifford Lectures. " 'I,' A Lecture on the Immortality of the Soul" was delivered in 1890 at the Finsbury Polytechnic and published in *The Family Churchman Conditional Immortality A Help to Sceptics* contained a series of thirteen letters written by Stokes in 1892 to James Marchant, a Christian Evidence Society lecturer in London. Marchant wrote Stokes that publishing these letters "would be the best way of showing the Secularist that the 'orthodox view' is *not* always held by our most eminent scholars."[42] He reported that "after a pretty long experience amongst working men I do not remember more than six persons who had looked at the subject of 'eternal torments' from the position of 'Life in Christ'!"[43] The third publication, "Is the Soul of Man by Its Nature Immortal?," was read at Sion College in 1893 Stokes rested his conclusions above all on Scripture, but also on everyday experience (especially fainting) and scientific knowledge.

As the true counter to the false doctrine of eternal torment, the concept of conditional immortality was Stokes's principal concern

[42] James Marchant to Stokes, 30 August 1892, Stokes Collection, M303

[43] Marchant to Stokes, 2 September 1892, Stokes Collection, M304 Marchant also published a letter from Stokes rejecting the "swoon" theory of Christ's resurrection in James Marchant, *Theories of the Resurrection of Christ* (London Williams and Norgate, 1899), pp 48-52

That Man consisted of something besides ponderable matter — something which could therefore be immortal — Stokes thought was shown by ordinary experience We retain our personal identities, as evidenced by memory, even though the matter of our bodies continually changes [44] At the end of a fainting spell, even a long one, our thoughts can flow continuously from their state before the spell, even though our always changing material bodies must have altered to some extent during the interval of unconsciousness (Stokes, " 'I,' " pp 6-7) The corollary of materialism, determinism, is so contrary to our sense of free will that the whole point of view flies "completely in the face of common sense" (p 8) Materialism was possible, Stokes thought, only for someone who thought the activity of ponderable matter sufficient to explain everything But such well-established scientific entities as luminiferous ether, magnetic force, and gravitation demonstrated the insufficiency of ponderable matter and mechanical principles by themselves (pp 8-10) Such "mysterious" agents seemed to require "something which we must regard as superadded to the mechanical properties of matter."[45] However, though "the materialistic hypothesis" was inadequate, so also was what Stokes called "the psychic theory," according to which Man consisted of body and soul, soul being inherently immortal and hampered in its functions because of its union with body. This view, also, Stokes argued, foundered on ordinary experience When the body became incapacitated — through, for example, fainting, injury, or near drowning — the soul was not liberated to think more clearly, quite the contrary (Stokes, " 'I,' " pp 10-12) Moreover, there existed no good, non-Biblical arguments in favor of the psychic theory [46]

More important for Stokes, neither was there Biblical authority for innate immortality The message of Biblical passages dealing with eternal life was that it was for the redeemed, the rest meeting extinction (Stokes, *Conditional Immortality*, p. 16). In John 3 16, for example, Jesus stated. "For God so loved the world, that he gave his only begotten Son, that whosoever believeth in him should not perish, but have everlasting life" (pp 72-73) Stokes cited Paul also: "He says later on, 'If the dead rise not, . let us eat and drink, for to-morrow

[44] G G Stokes, " 'I' A Lecture on the Immortality of the Soul, *The Family Churchman* (9 April 1890), pp 3-5

[45] Stokes, *Natural Theology*, II, 34 I hope to examine Stokes's views of the ether more thoroughly elsewhere They differed from his earlier views, for which see D B Wilson, "George Gabriel Stokes on Stellar Aberration and the Luminiferous Ether," *British Journal for the History of Science*, 6 (1972), 57-72

[46] G G Stokes, "Is the Soul of Man by Its Nature Immortal?," pp 129-132

we die ' How completely he ignores the Platonic doctrine of natural immortality of the soul "[47] Indeed, the concept of conditional immortality, the view of "Life in Christ," provided a basic insight into the Bible's true meaning "It is wonderful what harmony it introduces, both between one part of Scripture and another, and between the teaching of Scripture and what commends itself to our moral sense As a friend of mine in Cambridge, before whom I brought that view, said to me, 'Reading the Bible with that idea in the head is like turning a key in an oiled lock' " (Stokes, *Conditional Immortality*, p 19).

The theory of Man's tripartite nature, more ambiguous than the notion of conditional immortality, attempted to explain Man's present makeup and to understand what part survived death Again, there were two parts to the discussion, Biblical and non-Biblical The non-Biblical argument focused on the already mentioned insufficiencies of the psychic theory and involved the limitations of soul evidenced by its close association with thought and consciousness which were so frequently absent In the Gifford Lectures, Stokes, combining parts of the psychic and materialistic theories, postulated a deeper theory incorporating a third component

> May it not be there is a something constituting the *ego* which, on the one hand, is not to be identified with thought, and which may exist while thought is in abeyance, while, on the other, it is not to be identified with ponderable matter, but yet exercises over ponderable matter a sort of command? May it not be that thinking is a process which results from the interaction of the ego on the organism with which the ego is associated, over which it is, as it were, placed in command? According to this view, the ego is something lying deeper down in our nature than thought itself — something the destruction of which is not involved in the destruction of the body, inasmuch as it does not consist of ponderable matter — something which might conceivably, without any breach of continuity, preserve the personal identity between the man who died and the same man in some different stage of existence
>
> (Stokes, *Natural Theology*, I, 95)

Stokes speculated that thought would survive as a function of ego Ego might be able either to think by itself or through interaction with the "future body" which "is promised according to the Christian religion" (I, 97)

The argument to this point may appear somewhat thin. Has not Stokes needlessly conflated soul and thought, thus artificially creating the requirement for a third entity? Could not soul rather easily be made to serve the functions that Stokes reserves for ego? Regarding soul's connection to body, does not the cessation of thought in an in-

[47] Stokes, *Conditional Immortality*, p 70, and "Is the Soul of Man by Its Nature Immortal?, ' p 136 Paul's statement is in 1st Corinthians, 15 32

capacitated body support Plato's view more than Stokes's? Could not a Platonist readily answer Stokes's objections? However such questions might be answered, the historical point to be realized is that any weakness in the above arguments would, for Stokes, simply demonstrate the limitations of natural theology The real source of knowledge in these matters was not reason, but revelation

Precluded from discussing Scripture in the Gifford Lectures, Stokes stated merely that, contrary to Plato's theory that Man consists of body and soul, "in Scripture we have a threefold division, into body, soul, and spirit" (Stokes, *Natural Theology*, I, 102) The exegetical problem was to distinguish between spirit and soul On the back of a letter to him, Stokes listed nearly two dozen verses from the New Testament under the heading "spirit ≠ soul "[48] In print, he cited the creation of Man in Genesis where "we meet with the expression that God breathed into man's nostrils, after he was formed, 'the breath of life, and man became a living soul ' " Though one should not be naively literal about this passage, nevertheless, this "breath" or "spirit" according to Stokes, "is spoken of as a sort of energy, the interaction of which with the material organism produced a living being It is represented therefore, not so much as a living thing, but rather that which lay at the very basis of life, something deeper down even than very thought itself "[49] Moreover, Stokes pointed out, in Scripture "when that in man which is not put an end to by death is spoken of, it is not, I think, called 'soul,' but 'spirit ' "[50] For example, Luke 23.46· "And when Jesus had cried with a loud voice, he said, Father into thy hands I commend my spirit. and having said thus, he gave up the ghost " (This verse is listed on the back of Routh's letter)

Hence, Stokes thought that one's personal identity resided in one's spirit, or ego, not one's soul Spirit produced manifestations of life, like thought, through interaction with the body-soul component of the organism Spirit survived death, and those spirits meriting eternal life were provided, presumably at the time of the Judgment, with another body "What the nature of this body may be we do not know, but we are pretty distinctly informed that it will be something very different from that of our present bodies "[51] Though evidence re-

[48] E J Routh to Stokes, 2 November 1902, Stokes Collection, R1118 The notes by Stokes are undated but obviously date from the last few months of his life, as he died in February 1903

[49] Stokes, " 'I,' " p 14 He also discussed there Romans 8 10, one of the verses listed on the back of Routh's letter

[50] Stokes, " 'I,' ' p 15 Stokes gave as examples Acts 7 59 and Hebrews 12 23

[51] Stokes, " 'I,' " p 17 Stokes quoted from 1st Corinthians 15 35-37

There is *one* subject, and at present I can think of but one, to which these remarks do not apply, I mean the Mosaic account of the creation Here the writer professes to describe what could not be cognizable by man, and I see no alternative but either to accuse the writer of wilful falsehood, or accept the account as true *in some sense* The fact that our definition of day depends upon the sun, while Moses speaks of days prior to the account of the creation of the sun, releases us at once it seems to me from all *necessity* of interpreting the day to mean 24 hours One grand picture recurs through the Mosaic account — that creation was not a single act, but a succession of acts exerted at successive times And I know no other way of accounting for the fact, disclosed by geology, of the successive existence of different species and even genera and tribes of plants and animals inhabiting the earth For no attempt that has been made to refer this succession to second causes leaves on my mind the slightest shadow of satisfaction [53]

The letter expressed convictions which informed Stokes's writings over the next few decades. Though remaining opposed to evolutionary theory, he eventually found in "Scriptural evolution" a way of protecting his main conclusions from a possible, future verification even of human evolution

Stokes thought science and religion, ideally, would occupy their separate realms with no conflict, but the actual situation was more ambiguous. It was not that science, even in the ideal case, would be totally separate from religion, for Stokes thought that "man's mental powers, as well as his bodily frame, were designed to be what they are" (*Natural Theology*, I, 231) and that we cannot "imagine that God would deceive His creatures by giving them faculties the right exercise of which would lead to a conclusion at variance with" conclusions from revelation or from exercise of the moral faculties [54] However, though Stokes thought that science was always progressing, one "must not assume that everything in Nature is capable of explanation by purely scientific methods "[55] Moreover, "it appears to be *God's plan of dealing with man* not to make the evidence for revealed truth of that absolutely overwhelming character which should force assent" (Stokes to C. E Grove), and one should therefore be wary of confusing interpretation of Scripture with Scripture itself. Hence, in this complicated world, humans had to deal with different, incomplete, but Divinely sanctioned sources of knowledge — moral, Biblical, scientific. Squabbles could obviously arise as things were sorted out For example, in rejecting Galileo's arguments and the findings of early nineteenth-

[53] Stokes to C E Grove, 28 July and 8 September 1864, Cambridge University Library, Add Mss 5989, sheets 45, 46, 55, and 56

[54] G G Stokes, "Science and Faith," *Official Report of the Church Congress*, 33 (1893), 341

[55] G G Stokes, "The Luminiferous Ether," *Journal of the Transactions of the Victoria Institute*, 28 (1893), 90

century geology, churchmen had claimed too much for Scripture [56]

Stokes's view of the evolution of the solar system displayed the resultant interplay between sources of knowledge In the letter from 1864 quoted above, for example, Stokes did not abandon literal twenty-four-hour days because Genesis was unscientific, but instead because Genesis told of "days" before the sun existed. Genesis was "true in some sense " Stokes later noted that recent spectroscopical evidence supported Laplace's nebular hypothesis, according to which a nebula of non-luminous matter slowly condensed, first becoming luminous matter and eventually contracting sufficiently to form the sun The earth and the other planets formed from bits of the hot, luminous matter left behind in the process of condensation Thus, while the large, luminous nebula slowly shrank into a sun, the small, molten earth was more quickly cooling towards its present condition "It seems probable that the earth would have made considerable progress in its cooling, and what depends upon it, before the luminous matter inside its orbit would have collected into a definite sun "[57] A few years later he suggested another possibility: that the sun formed from a nebula on the first "day" but was not itself clearly visible from the earth until the fourth, when the earth's initial steamy atmosphere had cleared [58] Either way, the scientific account agreed well enough with the Biblical narrative. Light appeared on the first "day" well before the sun on the fourth, and that light nourished vegetation appearing on the third. That other details might not fit the scheme so well bothered Stokes little· "But if we suppose that the record in Genesis was meant for the people of the time, then it would be preposterous to demand scientific accuracy of detail A general rough accordance is all that we ought to expect; and that I think we have" ("Genesis and Science," p. 51) The sense in which Scripture was true thus lay somewhere between "slavish literalism" and scientific accuracy.

The history of the earth and its life raised similar conceptual problems Science both explained and indicated where explanation was impossible Laplace's nebular theory, for example, indicated a long history for the earth from molten mass to life-filled globe Geology

[56] Stokes, "Science and Faith," p 341, G G Stokes, "On the Absence of Real Opposition between Science and Revelation, *Journal of the Transactions of the Victoria Institute*, 17 (1883), 196, and G G. Stokes [Address at Annual Meeting], *Journal of the Transactions of the Victoria Institute*, 22 (1887), 17

[57] G G Stokes, "Genesis and Science, *Expositor*, 4th series, 3 (1891), 46

[58] Stokes to A H Tabrum, 17 August 1900, in Larmor, ed , *Memoir and Scientific Correspondence*, I, 86-87

demonstrated how dramatically the earth's surface and its life had changed At the same time, "the progress of science . leaves barriers which it gives no indication that science will ever be able to get over, nay, sometimes it makes the existence of such barriers more apparent "[59] Such barriers were the origin of life on the cooling earth and the gaps between widely different forms of animals whose fossils were preserved in geological strata Stokes saw "no prospect" of explaining these by the operation of natural causes.[60] Indeed, respecting the origin of life, "several persons who, in other respects, go in completely for evolution, allow that, in this case, something more is required "[61] Here, science provided evidence for God's intervention in nature, an intervention occurring "not merely at some indefinitely remote time which we please to contemplate as that of the origin of things," but at a time recent enough to be accessible to our understanding [62] And if in this instance "we must have recourse to some ultra-scientific cause, there is nothing unphilosophical in the supposition that this ultra-scientific cause may have acted subsequently also" (*Burnett Lectures*, p. 335). Subsequent acts included the origin of new sorts of animals, for detectable evolutionary processes were quite limited Darwin's pigeons were still pigeons, his finches still finches. Such restricted transmutations as these were clearly inadequate to "bridge over the enormous interval which separates an oyster from a man," and claims to the contrary were merely "utterly rampant" speculation [63] Once again, there was "general rough accordance" between science and Scripture, because, as Stokes stated in 1864, Genesis' "grand picture" portrayed God's creation as a succession of creative acts

The most important of these acts, of course, was the creation of Man Stokes, though still avoiding a *slavish* literalism, insisted on a Genesis interpreted more literally than in other cases. "In the account of the creation it is distinctly stated that man was separately created, 'in the image of God,' whatever that may imply. Nor is this a point in which by a wide licence of interpretation we might say the language

[59] Stokes, "On the Bearings of the Study of Natural Science," p 232 See G G Stokes, "Literature of the Day, and Its Attitude towards Christianity, *Official Report of the Church Congress*, 29 (1889), 212

[60] Stokes, "On the Bearings of the Study of Natural Science,' pp 235-236

[61] Stokes, *Natural Theology*, II, 181 Relevant to this point was nineteenth-century research, some of it done by Tyndall, which opposed the possibility of the spontaneous generation of life See Stokes, *Natural Theology*, I, 171, and G G Stokes, "Religious Benefits from Recent Science and Research," *Official Report of the Church Congress*, 19 (1879), 424

[62] G G Stokes, *Burnett Lectures On Light*, 2d ed (London Macmillan, 1892), p 331

[63] Stokes, "Religious Benefits from Recent Science and Research," pp 424-425

was merely figurative; that we can afford to understand it so, for that Scripture was not given to teach us Science" ("On the Absence," p 200). In addition, Biblical discussion of the origin and initial condition of human beings was not confined to Genesis. "They are dwelt on at length, in connexion with the scheme of redemption, by St Paul, and are more briefly referred to by our Lord himself, in connexion with the institution of marriage" ("On the Absence," p 201). Consideration of the moral faculties of humans reinforced the Biblical narrative Both internal inspection of one's own moral convictions plus examination of moral convictions in other cultures demonstrated the persistence of an innate sense of right and wrong even though people often behaved immorally [64] Man had been created innocent, but had fallen Against such impressive Biblical and moral evidence, evolution could offer "nothing more than a hypothesis of continuous transmutation, incapable of experimental investigation, and making such demands on our imagination as to stagger at least the uninitiated" ("On the Absence," p 201) In fact, "some even strongly pronounced evolutionists would seek something beyond evolution for the origin of man upon earth" (*Natural Theology*, II, 166) If humans were formed from animals by natural evolutionary processes, then it would be the Author of those processes, not humans, who was responsible for their sinful state [65] For such reasons, even stronger evidence should be required for a theory of human evolution than for other scientific theories "If some conclusion to which science seems to point throws a serious difficulty in the way of what we have been in the habit of considering was revealed to us, specially if it be a difficulty of a moral nature, we have a perfect right to demand severer evidence before we can accept it than what might have sufficed to lead us to regard it as in all probability true had there been no such appearance of opposition" ("On the Absence," p 204)

Unsurprisingly enough, it was Scripture, not science, which gave Stokes a way to allow for the possible verification of human evolution. In 1889, by which time evolution was becoming widely accepted, Reverend J. H Lamb sent Stokes a copy of his paper illustrating "evolution with Divine intervention by the Scriptural account of the Incarnation," which "struck me very much, and is I think calculated to do much good to some whose faith may be tottering in consequence of the supposed demands which science makes for the

[64] Stokes, "On the Absence,' p 201, and Stokes, *Natural Theology*, I, 224-233, II, 181-182, 197-198
[65] *Natural Theology*, II, 177, and "On the Absence," p 201

acceptance of evolution " In the Incarnation, "the first inception of the human life of the Incarnate Word was by a supernatural act of Divine power," but thereafter that life developed in an ordinary human way in the womb through childhood into adulthood "Here then is an instance of Divine Interposition, gigantic in its result, and yet of such a nature as not to offer any visible exception to the doctrine of evolution. of something superadded to, rather than running counter to, evolution."[66] Citing Lamb's argument in an 1892 letter to Marchant, Stokes declared that the assumption "that man took his origin by a supernatural modification of some previously-existing animal organism" was "a position which no study of evolution can overturn, or could overturn, unless we were prepared to account for the whole of the cosmos by mere natural causes, without the intervention of a Supreme Being."[67] This supposition as much required "a creative power as if man had been formed directly from materials not endowed with life "[68]

Scripture, science, and morality combined, therefore, to disclose a God who intervened in the course of nature in various ways He could act by fiat, leaving empirically detectable traces in the form of discontinuities in the universe's otherwise continuous development The origin of life was the most obvious such discontinuity, but the origin of species and the origin of Man were others God could also act by fiat, leaving no empirically detectable traces The Incarnation was the most important example, but if biologists could establish a convincing theory of human evolution, then the origin of Man would become another Third, God could act through established laws He could, for example, prevent the heat death of the universe suggested by the second law of thermodynamics, merely by utilizing natural laws to effect the statistically improbable, but possible, reversal of the dissipation of energy [69]

[66] Stokes's copy of his letter to Rev J S Exell, editor of the *Homiletic Magazine*, 17 April 1889, Stokes Collection, E241

[67] Stokes, *Conditional Immortality*, pp 43-44 See Moore's discussion of traducianism for a theological theory of human reproduction that helped some nineteenth-century Christians accept evolution James R Moore, *The Post-Darwinian Controversies A Study of the Protestant Struggle to Come to Terms with Darwin in Great Britain and America, 1870-1900* (Cambridge Cambridge University Press, 1979), pp 336-337

[68] Stokes, *Natural Theology*, II, 167 See Stokes to A H Tabrum, 7 August 1900, in Larmor, ed , *Memoir and Scientific Correspondence*, I, 85

[69] Stokes, "On the Bearings of the Study of Natural Science," pp 236-238 Stokes also thought the law of the dissipation of energy implied a Divine creation of the universe "we are obliged to refer to a First Cause " Stokes's remarks seconding acceptance of a report in *Journal of the Transactions of the Victoria Institute*, 20 (1885), 13

Opposed to Stokes's position was not the idea of accepting evolution as a working hypothesis to see where it would lead, but the militant contention that evolution was firmly established and, more important, that it had already led to materialism "Of course," Stokes explained, "we may assume evolution *for trial*, . but to adhere to it when there appears not the slightest prospect of its competence to account for the phenomenon presented does, I confess, seem to me to indicate an *animus* in the direction of endeavouring to dispense with a Creator" (*Natural Theology*, I, 170-171) It was one thing to trace evolutionary processes as far as possible, quite another to assume that they "must" suffice to account totally for the development of the earth and its life ("On the Absence," p. 198) Such a continuous connection between matter, animals, and Man would render Man not just another animal, which was bad enough, but a machine, thus doing away with morality and immortality (*Natural Theology*, II, 55-58) How can one hold a machine accountable for its actions? What part of our material bodies could be conceived to survive death?

IV

Tyndall provided the greatest animus in his "bold" and "unflinching" Belfast address, which Stokes thought, might turn out actually to aid the cause of religion

> In the attempt to deduce ourselves and our surroundings from that primeval condition of matter by mere evolution, by which I mean the blind operation of natural laws, he is obliged to endow with emotion the ultimate molecules of matter in a fiery nebula, and to adopt a series of conjectures against which common sense rebels The glove is boldly taken up, and the result is a *reductio ad absurdum* [70]

Tyndall's materialism may have led to a *reductio ad absurdum*, but it still warranted a specific alternative Stokes provided one with "directionism " It was an alternative Stokes outlined as early as 1879 and finally labeled in 1893 "To save circumlocution, I will coin a word, and call the view which I have been endeavouring to put before you *directionism* The alternative views would then be named materialism and directionism "[71]

[70] Stokes, ' Religious Benefits from Recent Science and Research," p 424 He felt the same two decades later 'Tyndall was led to attribute emotion to the ultimate molecules of matter in a fiery mass of gas!' (Stokes to A H Tabrum, 3 August 1900, in Larmor, ed , *Memoir and Scientific Correspondence*, I, 83)

[71] Stokes, *Natural Theology*, II, 47 The 1879 reference is Stokes, "Religious Benefits from Recent Science and Research," pp 421-422 He repeated the idea in 1880 in "On the Bearings of the Study of Natural Science, ' p 230

Directionism responded to Tyndall's use of the doctrine of the conservation of energy to help eradicate the distinction between life and non-life "Of still wider grasp and more radical significance" even than Darwin's theory, the conservation of energy, according to Tyndall in his Belfast address, " 'binds nature fast in fate' " to an extent not hitherto recognized, exacting from every antecedent its equivalent consequent, from every consequent its equivalent antecedent, and bringing vital as well as physical phenomena under the dominion of that law of causal connexion which, so far as the human understanding has yet pierced, asserts itself everywhere in nature."[72]

Disagreeing, Stokes explained that religious men should not worry that the law of the conservation of energy appeared to hold for living things as well as non-living The essence of directionism lay in that non-material aspect of a person which directed physical activity in the body without opposing it or holding it in check In contrast to that earlier kind of vitalism, Stokes envisioned "a directing power, not counteracting the action of the physical forces, but guiding them into a determined channel" (*Natural Theology*, II, 46) He used the analogy of a moving train, declaring that the human will was like "the intelligence of the engine-driver" not "the coals under the boiler."[73] Indeed, the fact that will appeared to lie outside the arena of energy conversions and transfers caused Stokes also to reject the conservation of energy as providing a relevant argument for immortality [74]

Directionism obviously dovetailed with Stokes's Biblically derived theories of conditional immortality and the tripartite nature of Man, though the latter's notion of potentially immortal ego-spirit was more refined and definite than directionism's notion of guiding will Moreover, by bringing before us the concept of one entity acting on another *entirely different*, directionism "led on to the contemplation of that mystery of mysteries, Will, . to the contemplation of Will, and of the effects of its exercise" (*Natural Theology*, II, 47, 54) Just as will influenced body, so also God did nature, both by independent fiat and through established law Furthermore, directionism resembled Stokes's scientific view of how non-mechanical gravity and ether operated on ponderable matter. In fact, Stokes preferred directionism to other forms of non-materialism because "that form of the alternative to materialism strikes me as being more nearly analogous to what we

[72] Tyndall, *Report of the British Association* (note 1) (1874), p lxxviii

[73] Stokes, "On the Bearings of the Study of Natural Science, ' p 230

[74] Stokes, *Conditional Immortality*, pp 32-34 See Rowell, *Hell and the Victorians*, p 205

know in science than are certain other forms" (*Natural Theology*, II, 55) Stokes did not think that natural science could demonstrate the reality of human immortality, but "I do think that natural science can, by pointing out the insufficiency of the materialistic hypothesis, remove the apparent incredibility of any such revival [*sic*, should be survival], so as to leave the mind open to weigh any evidence in favour of survival that may come from a totally different quarter" (II, 57). Consequently, directionism, with its analogical alliance with natural science, was strategically placed to counter materialism and its attendants, extreme evolution and scientific naturalism

Stokes was not only disputing Tyndall's application of the doctrine of the conservation of energy, in doing so he was also, in effect, using physics to adjudicate a dispute between biology and the Bible Contrasting current knowledge of biological and physical laws, for example, Stokes supposed "that biologists, as well as physicists, would allow that we know more about physics than we do about biology" (II, 236-237). Not only was physics more advanced than biology, but it had higher standards governing inferences made from available evidence: "[Darwin's] theory has been accepted by many eminent biologists with a readiness that is puzzling to an outsider, especially one accustomed to the severe demands for evidence that are required in the physical sciences "[75] When scrutinized by the standards of advanced modern physics, biological evidence was revealed as only adequate to support limited evolution, far short of the extreme, materialistic version being claimed Such an extreme view could be accepted, Stokes thought, only in spite of, not because of, biological considerations and only in the absence of legitimate religious considerations In addition, advanced modern physics disclosed to Stokes a world in harmony with the non-materialism of the Bible. Accepting geology's claims against the Bible and rejecting slavish literalism, Stokes fixed his moral and intellectual faculties upon the honest narrative of Jesus's character and teaching. Thus approached, Scripture joined with the methods and content of physics to define biology's present, and future, limitations.

Stokes evidently thought his idea of directionism was original, but, if so, he was wrong P G. Tait, a member of Stokes's audience in Edinburgh in 1893, referred Stokes to an article in the 1874 edition of Robert Chambers's *Encyclopaedia* in which he had written of the possible existence of a "vital force" which "is not a force which does

[75] Stokes, "On the Absence," p 200 He made the same point in "On the Bearings of the Study of Natural Science, ' p 235

work, in the mechanical sense of the term, but merely *directs*, as it were, the other natural forces *how to apply* their energies "[76] In fact, Tait's article appeared first in the 1862 edition of Chambers's *Encyclopaedia*. This was the same year he and William Thomson (later Lord Kelvin) published a popular article in *Good Words* on "Energy" in which they stated, "It seems even probable that it is actually through electric force that the energy of the food is placed at the disposal of that most inscrutable of finite, created, and subject agencies, a free will directing the motions of matter in a living animal "[77] Later, Kelvin, though without referring to energy considerations, drew the contrast between materialism and a religious notion of free will "The perception of every one of the human race of his own individuality and free will seems to me to absolutely disprove all materialistic doctrines and to give us scientific ground for believing in the Creator of the Univ[erse] in whom we live and move and have our being "[78] In addition, Balfour Stewart, Tait's collaborator on *Unseen Universe*, thought that life, like a military commander, is "a consummate strategist, who, sitting in his secret chamber, before his wires, directs the movements of a great army "[79] In turn, Stewart attributed to the physicist James P Joule, the physiologist William B Carpenter, and the German physicist-physiologist J R. Mayer the view that life "as far as energy is concerned, is not creative, but only directive "[80] The physicist Oliver Lodge carried the idea well into the twentieth century:

[76] P G Tait, "Force, Energy,' *Chambers's Encyclopaedia*, rev ed , 10 vols (London W & R Chambers, 1874), IV, 421 Stokes reported Tait's communication to him in *Natural Theology*, II, 47n

[77] William Thomson and P G Tait, "Energy, *Good Words* (1862), 605 Thomson and Tait's view on this question was one of the subjects discussed by Crosbie Smith in 'The Irreversible Cosmos William Thomson and the Universal Dissipation of Energy," read to the British Society for the History of Science, 6 July 1983

[78] Kelvin to Professor J Helder, 12 May [1906], printed in Wilson, "Kelvin's Scientific Realism," (note 9), p 60 There are many statements in this vein in Kelvin s writings, beginning as early as 1852 "On the Mechanical Action of Radiant Heat or Light On the Power of Animated Creatures over Matter On the Sources Available to Man for the Production of Mechanical Effect,' *Mathematical and Physical Papers* (note 7), I, 509

[79] Balfour Stewart, "The Conservation of Energy," in *Humboldt Library of Popular Science Literature*, no 7 (15 January 1881), 412 B Stewart and P G Tait, *The Unseen Universe, or Physical Speculations on a Future State*, new ed (London Macmillan, 1889)

[80] Stewart, "The Conservation of Energy," p 413 Carpenter, for example, affirmed the compatibility of two doctrines "that of the dependence of the Automatic activity of the Mind upon conditions which bring it within the *nexus* of Physical Causation, and that of the existence of an independent Power, controlling and directing that activity, which we call Will" (W B Carpenter, *Principles of Mental Physiology* [New York D Appleton and Co , 1874], pp ix-x) Carpenter, however, placed his concept of a directing power in the context of the notion of the ' correlation of forces," probably making it not so separate from other powers or energies as did directionism, which was conceived in the context of the more quantitative doctrine of the conservation of energy (On Carpenter, see Roger Smith, "The Human Significance of Biology Carpenter, Darwin, and the *vera causa*," in U C Knoepflmacher and G B Tennyson, eds , *Nature and the Victorian Imagination* [Berkeley University of California Press, 1977], pp 216-230)

"Life is not energy, it merely directs the energy which it finds available "[81] Whether Stokes was fully aware of it or not, he clearly was not alone in his concept of directionism.

We should see the context of Stokes's directionism, therefore, not only in terms of his specific scientific concepts and of his personal religious development. That religious part of the context did provide sufficient motive for him to use as he did his position of eminence in an increasingly eminent profession. Within that profession of science, however, there were divisions of discipline and viewpoint Not long after Kelvin had wielded thermodynamics against the geological uniformitarianism which undergirded the naturalism of Darwinian natural selection,[82] Stokes was pitting physics against biology and, thus, science against materialism Of similar view to Stokes's were the religious physicists Joule, Kelvin, Tait, Stewart, and Lodge Broadly speaking, Stokes's physicist's alternative to materialism represented an older, clergy-gentry, Newtonian tradition in counterpoint to the newer (and growing), middle-class, professional, scientific naturalism epitomized by the biologist-philosopher T H Huxley.[83] Without claiming that the context determined Stokes's idea of directionism, we can certainly see that the concept stood for more than itself

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[81] Oliver Lodge, *My Philosophy Representing My Views on the Many Functions of the Ether of Space* (London Ernest Benn, 1933), p 74 See also, Lodge, *Man and the Universe A Study of the Influence of the Advance in Scientific Knowledge upon Our Understanding of Christianity*, 2d ed (London Methuen, 1908), p 62 For studies of Lodge, see John D Root, "Science, Religion, and Psychical Research The Monistic Thought of Sir Oliver Lodge, ' *The Harvard Theological Review*, 71 (1978), 245-263, and D B Wilson, "The Thought of Late Victorian Physicists Oliver Lodge's Ethereal Body," *Victorian Studies*, 15 (1971), 29-48

[82] Using the physics of the day, Kelvin calculated that the cooling earth could only have been habitable for several million years, not for the virtually unlimited period of time envisioned by uniformitarian geologists He further argued that though evolution may have occurred, the earth had not been habitable long enough for evolution to have been caused by the slow process of natural selection, a process which he opposed also because it greatly decreased the amount of God's design in the world Kelvin s figures influenced late Victorian biological and geological thought, but the discovery of radioactivity in 1896 eventually led to the rejection of his value for the age of the earth (See Burchfield, *Kelvin and the Age of the Earth* [note 9], and D B Wilson, "Shaping Modern Perspectives Science and Religion in the Age of Darwin,' in D B Wilson and W D Dolphin, eds , *Did the Devil Make Darwin Do It? Modern Perspectives on the Creation-Evolution Controversy* [Ames, Iowa Iowa State University Press, 1983], pp 3-19) Regarding the perceived differences between biologists and physicists, Kelvin thought in 1903 that biologists were *returning* to his point of view "Modern biologists are coming, I believe, once more to a firm acceptance of something beyond mere gravitational, chemical, and physical forces, and that unknown thing is a vital principle ("Lord Kelvin on Science and Theism, *Nineteenth Century*, 53 [1903], 1069)

[83] Though Huxley, like Stokes, grew up with Evangelical Christianity, quite unlike Stokes he went on, of course, to champion evolutionary theory, write with facility on Hume and Kant, and harshly criticize Biblical authority

Harvey W Becher

THE SOCIAL ORIGINS AND POST-GRADUATE CAREERS OF A CAMBRIDGE INTELLECTUAL ELITE, 1830-1860*

WHETHER OR NOT PRESENT-DAY HISTORIANS ACCEPT A CLASS DESCRIPTION OF English society, nineteenth-century English pedagogues did They perceived a three-tiered division of upper (landed) class, middle class, and working class, and the need for a three-track educational system to match Although radicals attacked the public schools and Oxford and Cambridge Universities for failing to meet the needs of the middle classes, the schools and Oxbridge steadfastly refused to change Theirs was a "liberal education" concerned not with modern languages, business procedures, and similar middle-class needs, but with mental training, character building, and religious indoctrination [1]

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[1] See R L Archer, *Secondary Education in the Nineteenth Century* (1921, rpt ed , London F Cass, 1966), J W Adamson, *English Education, 1789-1902* (1930, rpt ed , Cambridge Cambridge University Press, 1964), Edward C Mack, *Public Schools and British Opinion, 1780-1860* (London Methuen, 1938), W G H Armytage, *Civic Universities, Aspects of a British Tradition* (London Ernest Benn Ltd , 1956), Robert McPherson, *Theory of Education in Nineteenth Century England* (Athens University of Georgia, 1965), Brian Simon, *Studies in the History of Education* (London Lawrence and Wishart, 1960), W R Ward, *Victorian Oxford* (London F Cass, 1965), T W Bamford, *The Rise of the Public Schols* (London Nelson, 1967), Brian Henney, *Mission to the Middle Classes The Woodward Schools, 1844-1891* (London Society for Promoting Christian Knowledge, 1969), N W Saffin, *Science, Religion and Education in Britain, 1804-1904* (London Lowden, 1973), Brian Simon and Ian Bradley, *The Victorian Public School* (Dublin Gill and Macmillan, 1975), Sheldon Rothblatt, *Tradition and Change in English Liberal Education* (London Faber and Faber, 1976), Martha McMackin Garland, *Cambridge Before Darwin* (Cambridge Cambridge University Press, 1980) That the English pedagogues reflected the class consciousness of their time does not substantiate the class conflict explanation of how English education developed See Sheldon Rothblatt, *The Revolution of the Dons* (New York Basic Books, 1968), pp 15-26, Michalina Vaughan and Margaret Scotford Archer, *Social Conflict and Educational Change in England and France* (Cambridge Cambridge University Press, 1971), pp 10-15

The lack of any professional training was no great handicap because the clientele at the public schools and Oxbridge was exclusive T W Bamford determined that between 1821 and 1850, the parentage of students at the eight "dominant" public schools — Eton, Harrow, Winchester, Rugby, Shrewsbury, Charterhouse, St Paul's, and Westminster — was 67 percent gentry and titled, 17 percent clergy, 7 percent professional, 5 4 percent military, 2.9 percent middle class, and .6 percent lower class.[2] Although Cambridge students had somewhat more diverse origins, the middle and lower classes were not broadly represented Between 1800 and 1849, according to Hester Jenkins and D Cardog Jones, 31 percent of the Cambridge fathers were landed, 32 percent clergy, 19 percent professional (law, medicine, and teaching), 8 percent middle class (business, banking, public administration, and other "profit-making" occupations), and 10 percent miscellaneous.[3]

Most of these Cambridge matriculants graduated as poll-men, that is, with ordinary degrees; less than one-third took honors, partially, at least, because the honors curriculum was severely restricted. Prior to 1849, achieving mathematics honors was prerequisite to competing for classical honors, and until 1851, honors degrees could only be won in these two mainstays of a Cambridge liberal education Even after 1851, when the Natural Sciences Tripos and the Moral Sciences Tripos were offered for the first time, the older studies continued to dominate So few students took the new triposes that their survival was in doubt as late as 1860.[4]

Even though the new triposes had little immediate impact, their establishment, along with the unfettering of the Classical Tripos from mathematics, foreshadowed the triumph of specialization and the demise of a traditional liberal education [5] Pre-1861 mathematics

[2] T W Bamford, "Public Schools and Social Class, 1801-1850," *British Journal of Sociology*, 12 (1961), 224-235 The data cited are extrapolations from Table 3 on p 229 The percentages are adjusted frequencies, that is, unknowns are not included in the calculations All percentages given in this paper are adjusted

[3] Hester Jenkins and D Cardog Jones, "Social Class of Cambridge University Alumni of the 18th and 19th Centuries," *British Journal of Sociology*, 1 (1960), 93-116 The figures cited are extrapolations from Table 1 on p 99 In *School and Society in England Social Backgrounds of Oxford and Cambridge Students* (Washington, D C Public Affairs Press, 1951), C Arnold Anderson and Miriam Schnaper gave a more aristocratic heritage to Cambridge students for the time span 1752-1886

[4] Joseph B Mayor, *Remarks on the Proposal to Grant the Degree of B A to Persons who Have Obtained Honours in the Moral Sciences Tripos* (Cambridge, 1860), Cambridge University Library, Cam c 860 30, William George Clark [Flysheet no title] (Cambridge, 1860), Whewell Papers, Trinity College Library, Cambridge University, Add Mss a 62[46]

[5] H A Morgan, *The Mathematics Tripos An Inquiry into Its Influences on a Liberal Education* (London J Murray, 1871), pp 3-9, in *College Pamphlets*, 1403, Beinecke Rare Book Library, Yale University, Isaac Todhunter, *The Conflict of Studies and Other Essays on Subjects Connected with Education* (London Macmillan, 1873), pp 5-6, 25-28, 31, 193-197, and 213-217

honors graduates constituted almost the last of an academic elite perceived not as specialists, but as gentlemen eminently qualified to pursue any career after graduation This is not to say that all shared equally in intellectual acclaim Successful honors candidates were assigned to and ranked within one of three divisions, the division of "wranglers" being the highest with the first or senior wrangler enthroned at the head of the list This essay is an analysis of the social origins and post-graduate careers of the elite among the elite, of the ten highest wranglers for each of the years from 1830 to 1860 when the number of wranglers varied between a low of thirty (1834) and a high of forty-six (1837)

Two different methodologies are employed in this study, the first being prosopographical All prosopographical endeavors encounter the difficulty of fitting a wide variety of individuals into one of a few specific categories This paper confronts added problems. First, the data for it (as for the study of Jenkins and Jones) are culled from John and J. A Venn, *Alumni Cantabrigienses* (Cambridge· Cambridge University Press, 1922-1954). In it, the wrangler-supplied data for their fathers are a mix of social classes and occupations, and fit Victorian perceptions rather than present-day sociological ones.[6] There appears to be no escaping this inconsistency in a manner which would not be to some degree arbitrary and destructive of the meaning the traditional labels had and have, at least for historians For the careers of the wranglers themselves only occupational labels work, which in itself indicates generational change

Another problem results from the need to embed the wranglers in their historical context by means of comparison to public school attendees and the general run of Cambridge students. Here the classifications necessarily follow those of Bamford and of Jenkins and Jones Where such comparisons are not the objective, different criteria are more appropriate, and modification of taxonomies becomes necessary To avoid confusion, pertinent explanations of recodings, specific constituents of taxonomies, and relevant *caveats* are given either in the text or in the notes

The chief asset of the prosopographical approach lies in its usefulness in establishing general patterns free of impressionistic distortions This benefit can be maximized if and only if the anonymity of the particulars is maintained Mere abstractions of course do not

[6] For the slowly emerging concept of social class in Victorian Britain and the problems this presents for historians, see Asa Briggs, "The Language of 'Class' in Early Nineteenth-Century England," in M W Flinn and T C Smout, eds , *Essays in Social History* (Oxford Clarendon Press, 1974), pp 154-177

make history Therefore, having allowed prosopography to pencil the sketch, we will paint in the details with specific individuals, events, and circumstances At the same time, cliometric parameters will guide interpretations balanced between empathy for the nineteenth century and concern for present-day perspectives

This composition of methodologies results in a view of history with a broader focus than that usually encountered in the history of science For instance, it is already widely recognized that Cambridge graduated most of the outstanding British mathematicians and mathematical physicists of the nineteenth century The approach here shows that Cambridge educated the educators who staffed many of the institutions emerging as centers of scientific activity. This finding calls for a reevaluation of Cambridge in the history of science, and when it and other findings are extended to the wider British cultural context, similar questions arise about Cambridge's role in society-at-large As a result, this essay touches upon a broad spectrum of historical issues including the role of mathematics (and science) in nineteenth-century British society, the social class composition of the Victorian intelligentsia, the history of higher education, and, at least tangentially, the "decline of England" debate

I

The parentage of the wranglers diverged from that of boys at the dominant public schools and from the mass of Cambridge matriculants Only 7 7 percent of the wranglers' fathers can be positively identified as titled or gentry, whereas 67 percent of the schoolboys' fathers were of that class.[7] Adding fathers identified by other than profession to those positively identified as titled or gentry (the category designated Upper Class in Table 1) and placing gentry-fathers whose professions are known in the pertinent professional rather than Upper Class category in the manner of Jenkins and Jones, reveals that 21.2 percent of the wranglers' fathers were upper class as compared to 31 percent of the fathers of all Cambridge students Fewer

[7] The percentage for the schoolboys is an extrapolation from Table 1 in Bamford, "Public Schools," p 225 P Burk, *Geneological and Heraldic History of the Landed Gentry of Great Britain and Ireland*, 2 vols (London Harrison, 1882), was used to establish gentry status for the fathers of wranglers, other publications were not used in the prosopographical analysis so as not to skew the collective analysis toward outstanding individuals

wranglers had fathers in the clergy (about the same percentage as Bamford's public school students) The most remarkable disparity lay in the percentage of the wranglers' fathers in middle-class occupations, four and ten times as great as for Cambridge and the dominant public schools respectively Adding the professional fathers to this category gives a majority of the wranglers middle-class status [8]

Other data tend to confirm that the majority of wranglers were middle class The wranglers, as all Cambridge students, matriculated as members of one of four castes None of the wranglers entered as noblemen, two as Fellow Commoners (those willing and able to pay for the privileges accorded legally recognized noblemen), 223 as pensioners who paid regular fees, and eighty-two as sizars subject to minimal fees [9] Of the 220 wranglers for whom information concerning their pre-Cambridge schooling has been obtained, the percentage attending public schools was about the same as other Cambridge students. However, only 22 8 percent came from what have been classified as the twenty-three "foremost schools," about one-half the percentage of other Cambridge students, and only 10 5 percent attended a dominant public school.[10] The wranglers attended 124 different schools (some more than one). Of these, the newly founded London colleges were the most popular Twenty-five future wranglers attended King's College, London, the Church's 1831 creation designed to counterbalance the 1828-founded "Godless" University College,

[8] The specific designations for the middle-class fathers are nineteen merchants, eight skilled tradesmen (two bricklayers and a plasterer, a painter, a butcher, a hatter, a woolstapler, and a silversmith), five bankers, three brewers, three drapers, three manufacturers, an unsuccessful manufacturer, three yeomen, two farmers, two tenant farmers, a crofter, a woolen dealer, a master of a feltmaking company, a cotton manufacturer, a silk manufacturer, a corn dealer, a bookseller, a miller, a shipowner, a naval outfitter, a grocer, a wholesale stationer, a mercer, an iron-monger, a calico-printer, an auctioneer, an agent, a land agent, a mineral agent, a public administrator, an architect, and an engineer The professionals are nineteen lawyers, fifteen medical men, seven schoolmasters, three university professors, and one lawyer's clerk Thirteen military fathers, for whom Jenkins and Jones have no separate classification, a master of ceremonies at Bath, and a secretary to a Duke make up the miscellaneous group Upper-class fathers identified by other than profession were twenty-four esquires, ten gentlemen, two "of House," one Sir, and two cases where the sons listed themselves as "son and heir " Nine gentry fathers classified by profession were six clergymen, one merchant and one public administrator (middle-class), and one lawyer (professional)

[9] Anderson and Schnaper, "School and Society," p 44 report that in 1800 about one-sixth of the Cambridge students were noblemen, about one-half were Fellow Commoners and pensioners, and the rest were Foundation Scholars (outstanding students for whom the colleges provided) and sizars This is confusing because students entered as noblemen, Fellow Commoners, pensioners, or sizars, and any could become scholars, as did 214 of the wranglers in this study

[10] For Cambridge students in general, see Jenkins and Jones, "Social Class," p 102 The division between public and other schools used here follows that of Jenkins and Jones Their "foremost public schools' include, in addition to the eight "dominant" schools (see above), Cheltenham, Clifton, Fettes, Haileybury, Loretto, Malvern, Marlborough, Merchant Taylors, Oundle, Radley, Repton, Rossall, Sedberg, Sherbourne, and Uppingham

London, where ten of the to-be wranglers studied Eight enrolled at Christ's Hospital, an "ancient endowed school" in London which was "distinguished for teaching mathematics "[11] Nine attended Scottish universities where "democratic education" reigned [12] Of the foremost public schools, Rugby and Eton led the way, each producing six wranglers, the same number as the City of London That so many of the wranglers attended schools other than the prestigious public schools suggests non-gentility, and despite criticism of drawing conclusions concerning the social class of Cambridge students on the basis of their school attendance, the evidence differentiating the wranglers from the general run of Cambridge students is overwhelming [13]

The geographic origins of the wranglers (the location of the family home if given, birthplace if not) tended to be urban rather than rural The majority of wranglers came from the environs of London and the textile manufacturing counties Of the 260 English wranglers, 36 percent were from cities with more than 100,000 residents, 10 9 percent from cities of populations greater than 25,000, 6 9 percent from smaller towns, and 7.2 percent from parts of counties included within the Metropolitan London Police District of 1839, a total of 61 percent Greater London, with a population of 1,778,000 in 1831, produced a disproportionate (even for its great population) share of wranglers, 26 3 percent Only three counties produced 5 percent or more of the wranglers Two were the most populous of all counties: Yorkshire (9 7 percent) and Lancashire (6 6 percent) The other was Hampshire (5 percent) Yorkshire and Lancashire were centers of wool and cotton manufacturing with populations of 1,372,000 and 1,337,000 respectively Hampshire, with a population of only 336,000, had more of an agriculturally based economy and a high proportion of its land given to large estates,[14] but six of its thirteen wranglers were

[11] W H Brock, *H E Armstrong and the Teaching of Science, 1800-1930* (Cambridge Cambridge University Press, 1973), p 31

[12] George Elder Davie, *The Democratic Intellect Scotland and Her Universities in the Nineteenth Century* (Edinburgh University of Edinburgh Press, 1961)

[13] Rothblatt, *Revolution of the Dons*, pp 57-59, has specified the need to differentiate between day boys and boarders and to know what expenses were defrayed by grants However, at Eton, Harrow, Rugby, Winchester, Shrewsbury, Westminster, and Charterhouse, all boys paid fees and poverty qualifications for the few scholarships were ignored (Simon, *Studies in the History of Education*, p 315) Bamford, "Public Schools," has demonstrated the social exclusiveness of the ' dominant" public schools, or at least of Harrow, Rugby, St Paul's, and Eton which he analyzed in detail, and Jenkins and Jones, "Social Class," pp 102-106, provide some evidence that their twenty-three foremost schools had a more exclusive student body than other schools Moreover, the disparity between the wranglers and other Cambridge students in attendance at the foremost public schools is greater than the figures indicate The percentage for all Cambridge students is for the years 1800 to 1849, for the wranglers, 1830 to 1860, and nine of the foremost schools were not yet in existence in 1844 (Rothblatt, *Revolution of the Dons*, p 57)

[14] F M L Thompson, *English Landed Society in the Nineteenth Century* (London Routledge and Kegan Paul, 1963), pp 113-115

TABLE 1: FATHERS' PROFESSIONS

	Absolute Frequency	Adjusted Frequency (%)
Middle Class	71	32 0
Upper Class	47	21 2
Professional	45	20.3
Clergy	44	19 8
Miscellaneous	15	6.8
Total	222	100.1

TABLE 2: WRANGLERS' PRIMARY PROFESSIONS

	Absolute Frequency	Adjusted Frequency (%)
Clergy	93	31.4
Higher Education	68	23.0
Other Professional	56	18.9
Lower Education	43	14.5
Other Academic	16	5 4
Govt. Admin	10	3.4
Business	10	3 3
Total	296	99.9

from Portsmouth/Portsea, and six of their fathers were professionals, one a businessman (five fathers are unknown) Similarly, seven of the twenty Scottish wranglers came from cities larger than 50,000 This suggests that the middle-class wranglers were most likely to be of the world of commerce and to a lesser extent that of the established textile industry, a suggestion confirmed by the specific occupations of their fathers [15]

None of the wranglers appear to have been Dickensian poor or sons of the industrial working class, not even those holding sizarships which supposedly were reserved for the poor In fact, eight fathers of sizars also sent up to Cambridge one (or more) less talented sons as pensioners, and the son of a merchant and insurance agent in London attended school in Paris and was admitted at Lincoln's Inn before accepting a sizarship Entering at the Inns of Court demanded some form of subsistence for the term of the legal apprenticeship (usually about three years). Yet four other sizars entered the Inns of Court upon graduation without any visible means of support, and the sizar son of a banker received a Fellowship the year after entering upon his legal apprenticeship. Furthermore, those sizars without obvious financial means often had patrons to pave their way to Cambridge One tenant farmer father, a Nonconformist, held his tenancy from the Duke of Devonshire The Duke had intimate ties with Trinity College, where the son enrolled Likewise, the mathematical talents of an apprentice shoemaker *cum* sizar were noticed by Lord Brougham, who had him educated. Mathematical talent rather than poverty was the key that opened doors at Cambridge

Another key was religion Only fifteen of all wranglers can be identified as non-Anglicans, and five of these were Presbyterians Only Presbyterians could take a degree without swearing to the Anglican faith. Other non-Anglicans, of whom two were Jews and eight were Christians, faced tremendous pressures to conform It is not surprising that seven non-Anglican, non-Presbyterian wranglers took degrees or that the three who did not take degrees entered the law. For those less well off, to have suffered through the discrimination as well as the pain of studying for and competing in the Tripos without gaining the benefits of a degree would have demanded courageous character indeed [16] The removal of religious tests for degrees in 1858 and for

[15] See note 8

[16] For the pressures on non-Anglicans, see [John Eyton Bickersteth Mayor], *In Memorium Isaac Todhunter* (Cambridge, 1885), Cambridge University Library, Cam d 884 7 For the anxieties created by academic competition, see Sheldon Rothblatt, "Failure in Early Nineteenth-Century Oxford and Cambridge," *History of Education*, 11 (1982), 1-21

Fellowships in 1871 benefitted non-Anglicans, especially the poor among them.

Regardless of their social origins, most wranglers were "first generation" university graduates Only thirty-one of the fathers were Cambridge graduates (twelve were wranglers). In addition, one father was admitted but not graduated. Only twelve fathers can be identified as having graduated from other universities, ten from Oxford, and two from Edinburgh Nineteen of the Cambridge fathers were clergymen, as were seven of the Oxford graduates Five professional fathers were Cambridge graduates, and two were Oxford graduates Three upper-class fathers were Cambridge alumni while one was an Oxford alumnus Just three of the seventy-one middle-class fathers graduated from a university, all of them from Cambridge The wranglers entered Cambridge, except perhaps for the sons of clergymen and academics, not as preparation to take up the mantles of their fathers, but to gain the benefits of a liberal education and a Cambridge honors degree

II

The wranglers enjoyed a wide choice of careers Observe the number of them who entered more than one field: 212 of the 296 for whom some occupation could be ascertained; and the number of different careers pursued, at least twenty-five. Yet, there was a consensus about where the "good life" lay: 42.9 percent of the wranglers opted for academe as their primary profession[17] (the composition of the "Higher Education," "Lower Education," and "Other Academic" categories in Table 2) That 31 7 percent entered the church certainly belies the adage that only poll-men became clergymen.[18] The only other popular choice was the law, which attracted fifty-two of the wranglers (included with two physicians, a naval architect, and a naval officer in the "Other Professional" category) Business and non-education-related Government Administration (education administration is included in lower education) attracted only 3 4 percent each, and only one wrangler appears to have adopted the landed way of life ("lived nobly") Cambridge graduates in general tended more than the wranglers toward the church and

[17] The primary or first career of a wrangler with more than one career was determined on the basis of duration Where no clear-cut decision could be made on that basis, the earlier career became the primary career Ninety-eight had three occupations, and twenty-seven followed four or more professions (only four fields were allocated to professions on the data cards)

[18] Garland, *Cambridge Before Darwin*, p 7

living nobly and less toward business, teaching, and the law.[19]

Before proceeding further with the analysis of the wranglers' careers, the three categories constituting academe require clarification First, ten of the "other academics" (fourteen mathematicians, one biologist, and an historian) had secondary careers in higher education and might be considered elements of that category [20] Second, the line between lower and higher education, as with all taxonomic devices for nineteenth-century British education, is difficult to define The separation in Table 2 is not based on legal definition, social status, or economic factors There was no legal definition of "lower" or "higher," and wranglers in lower education, except for the government education administrators, were most often masters or assistant masters at prestigious public schools, possibly better off socially and economically than some of their colleagues at "universities " Therefore, the line in this study is based upon whether or not higher mathematics was likely to be taught in the institution. On this basis, higher education includes in addition to all universities, schools which either had professorships rather than tutorships or "modern" sides to their curricula which included mathematics and/or science [21]

The three segments of academe obviously blended one into another Taking into account secondary careers reveals that the wranglers not only moved within academe freely, but even more freely into and out of the church, and from law into academe Nearly 19 percent of the wranglers in lower education also held positions in higher education, 11 3 percent with primary careers in higher education also had careers in lower education. Both groups were intertwined with the church. 59 5 percent in lower education and 26.4 percent in higher education also had careers in the church, and, conversely, 52 8 percent of the clergy had secondary careers in lower education while 32 percent also entered higher education. As for the lawyers, though 44.4 percent of them understandably also had careers in government, even more, 47.2 percent, had secondary academic careers (38 9 percent in higher education, 5 6 percent in lower education, and 2.8 percent in the "Other Academic" classification).

[19] Jenkins and Jones, "Social Class, p 99

[20] A wrangler had a primary career as an "other academic" if his contribution to his discipline could be considered more important historically than his other activities Mathematicians here as in Victorian England include mathematical physicists

[21] Non-university-titled schools classified as institutions of higher education at which wranglers held positions are military academies and naval schools, East India Company schools, Cheltenham, Owen's College, Birmingham, the Royal Observatory, Greenwich, Leeds College, Liverpool College, the Royal School of Mines, the Royal College of Science, and the College of Civil Engineering, Putney

There can be no doubt that the wranglers became professionally homogeneous 74 3 percent entered church-academe and 17.5 the law, for a total of 91 8 percent, and they often moved within these professions At least to the extent that profession determines social class, they were also socially homogeneous.

The early classification for the fathers designed for comparison purposes (Table 1) can be improved for determination of social mobility There are more upper-class fathers in Table 3 than Table 1 because the gentry fathers with known professions are classified as Upper Class rather than by profession as in Table 1; of course, the respective occupational groups lose these fathers (see note 8). The professional fathers in both Table 1 and Table 3 are eighteen lawyers, fifteen medical men, seven schoolmasters, two university professors, and a lawyer's clerk, professional fathers added to Table 3 are thirteen military men, a Master of Ceremonies at Bath, a secretary to a Duke (classified as Miscellaneous in Table 1), and an architect and an engineer (classified as Middle Class in Table 1) The Clergy and Middle Class categories remain in Table 3 as in Table 1 except for losses to the Upper Class and, in the case of the Middle Class, to the Professional grouping

Regardless of the classificatory system employed, some wranglers followed in their fathers' footsteps upon entering church-academe: eight of the nine sons of the schoolmasters and university professors and 83.7 percent of the clergymen's sons did However, 72 percent of the sons of other professionals, all eight sons of skilled tradesmen, 87 5 percent of the farmers' sons, and 67.7 percent of the businessmen's sons also entered church-academe; none of the skilled tradesmen's sons, and only 10 percent of the farmers' sons and 11 percent of the businessmen's sons returned to profitmaking Overall, 77.8 percent of the middle-class offspring turned to church-academe and 11 1 percent entered other professions. A Cambridge liberal education estranged these sons of capitalists from the "productive" realm.

The wranglers' education did not, however, alienate them from their social superiors as defined by birthright More than 62 percent of the wranglers with fathers in the upper class chose primary careers in church-academe And of the eighteen sons of lawyers, thirteen went into church-academe, three followed law careers, one entered government, and one became an engineer The careers of the thirteen wranglers with fathers in the military also are worth analyzing both because historians assume a close tie between the British landed class

TABLE 3: FATHERS' PROFESSIONS BY WRANGLERS' PRIMARY PROFESSIONS
(absolute frequency and adjusted row frequency)

	Wranglers' Primary Professions							
Fathers' Professions	Lower Education	Higher Education	Other Professions	Clergy	Other Academics	Govt. and Administration	Business	Total #
	11	16	7	17	5	1	6	
	17 5%	25 4	11.1	27 0	7 9	1 6	9 5	63
Middle Class	7	14	12	20	3	2	2	
	11 7	23 3	20 0	33 3	5 0	3 3	3 3	60
Professional	5	10	17	14	4	2	1	
	9 4	18 9	32 1	26 4	7 6	3 8	1 9	53
Upper Class	6	10	5	13	2	1	0	
	16 2	27 0	13 5	35 1	5 4	2 7	0 0	37
Clergy								
TOTAL #	29	50	41	64	14	6	9	213

TABLE 4 *DICTIONARY OF NATIONAL BIOGRAPHY* **BY TRIPOS RANK**
(absolute frequency and adjusted column frequency)

	Tripos Rank										
DNB	1	2	3	4	5	6	7	8	9	10	Totals
Listed	14	13	8	4	6	7	7	2	2	0	63
	46 7%	40 6	24 2	12 9	20 7	21 9	23 3	6 5	5 9	0 0	20 3
Not Listed	16	19	25	27	23	25	23	29	32	29	248
	53 3	59 4	75 8	87 1	79 3	78 1	76 7	93 5	94 1	100 0	79 7
Totals	30	32	33	31	29	32	30	31	34	29	311

and the military, and because as wranglers they were well-trained in applied mathematics, which prepared them for military careers [22] Only one of the thirteen pursued a career in the military Another became an engineer, one entered lower education, five followed careers in higher education, and the remaining five joined the church Despite being well-prepared in mathematics, having fathers in the military and perhaps connections with the landed class which would have made success in the military likely, these wranglers, like their peers, opted overwhelmingly for church academe.

To some extent the wranglers went where the jobs were Law, education, and the church were among the most rapidly expanding professions On the other hand, post-Napoleonic military opportunities were not great, and in the second half of the nineteenth-century the landed way of life began to feel the pressure of free trade and competition from industrial wealth [23] Yet, with their family connections, many of the wranglers could have made their way in these fields, and certainly in business Their overwhelming preference for careers in the church, academe, and the law cannot be denied.

In their chosen professions, the wranglers earned the esteem of society, or at least that segment of society represented in the *Dictionary of National Biography*, which registered 20 3 percent of them [24] Several factors affected a wrangler's chances of being included in the *DNB*, one being his primary profession He was most likely to be included in the *DNB* if his main profession was in the anomalous "other academic" category,[25] least likely if in lower education, the church, or business Family status was less of a factor, except at the extremes of the social spectrum: the *DNB* bypassed all of the skilled tradesmen's sons but listed 47 1 percent of the sons of fathers positively identified as

[22] For the military-landed connection, see C B Otley, "Social Origins of British Army Officers," *Sociological Review*, 18 (1970), 213-140, Anderson and Schnaper, "School and Society," p 10, Fritz Ringer, "The Education of Elites in Modern Europe," *History of Education Quarterly*, 18 (1978), 159-172, on pp 160-161, Thompson, *English Landed Society*, pp 9, 22, 51, 61-63, 71-75, 128, 287 For the applied orientation of the mathematics curriculum, see A B A , *University Education*, p 8, Harvey W Becher, "William Whewell and Cambridge Mathematics," *Historical Studies in the Physical Sciences*, 11 (1980), 1-48

[23] Bamford, "Public Schools," p 231, C K Francis Brown, *A History of the English Clergy* (London Faith Press, 1953), p 237, Thompson, *English Landed Society*, pp 238-268

[24] The percentage of wranglers mentioned in the *DNB* declined significantly for the later periods of this study Of those taking the Tripos between 1830 and 1839, 30 7 percent were listed in the *DNB*, 1844-1849, 19 percent, 1850-1860, 11 8 percent Thus, 49 2 percent of those included in the *DNB* graduated in the first period, 30 2 percent in the second, and 20 6 in the third No significant correlation between this trend and any other variable using the above time spans as controls could be found The likely explanation is that the later wranglers lived too long to be included in the original *DNB* (their mean, mode, and median age at the time of taking the Tripos were 22 4, 22 0, and 22 0 respectively, and of their ages at death 69, 74, 73) The *Supplements* to the *DNB* were not as comprehensive as the original

[25] By definition (see note 20), most of the other academics would be included in the *DNB*

titled or gentry. However, another variable overrode both the wranglers' lineage and their choice of first profession a high Tripos finish. Forty percent of the twenty clergymen, one of the nine in lower education, and one of the three businessmen gaining one of the first three Tripos positions achieved *DNB* recognition; of those who ranked seven through ten, only 6 5 percent of the thirty-one clergymen, and none of the twenty-two wranglers in lower education or the six in business were so recognized And even if a high Tripos finish could not overcome the handicap of having a skilled tradesman for a father, neither could having a father of the landed class overcome a lower finish on the Tripos. Six of the eight titled or gentry sons who were ranked first, second, or third in the Tripos gained *DNB* inclusion, but none of the five who ranked seven through ten did

Indeed, the most important variable in achieving or not achieving *DNB* recognition was the wrangler's position on the Tripos (see Table 4) [26] This was meritocratic, for the Tripos did not play favorites The strongest correlation of any variable with the wranglers' rankings was their fathers' professions, the best performance was turned in by the sons of middle-class fathers, of whom 59.9 percent gained one of the five top positions, while the worst performance was by the upper-class sons, only 46 4 percent of whom finished among the top five. To a high degree the Tripos acted as an "equilizer," offered opportunity for all to "become somebody" The contemporary caricature of the scrimping sizar who "persevereth in his studies silently unto the end, and turneth out Senior Wrangler — by which both he and his family are rich to the ends of their lives" was not without a kernel of truth [27] For these gifted mathematicians, a liberal education tended to erase rather than mark class lines

III

Categories and percentages do not make history, in fact they may be inadequate indicators of what actually happened Take the case of the sixth wrangler of 1859, Robert Bellamy Clifton After a sojourn as Professor of Natural Philosophy at Owen's College, Manchester, from 1860 to 1865, Clifton occupied the Professorship of

[26] The different number of wranglers for each rank is due to numerous cases of "bracketing" two or more wranglers where a tie for a position could not be broken Where bracketing occurred, all wranglers tied were given the highest rank, and the next wrangler the position which would have been his assuming differentiation had been made between the tied wranglers

[27] "Characters of Freshmen," *Cambridge University Magazine*, 1 (1840), 179

Experimental Philosophy at Oxford until he died in 1915 Unfortuntely for physics at Oxford, the verb occupied is apt After carefully overseeing the establishment of the Clarendon Laboratory, Clifton refused students access to it, "retired without resigning; and by faithful abstinence from both teaching and research preserved himself and his professorship for over half a century "[28] At Oxford's sister university, it was not until 1871 that the largess of the seventh Duke of Devonshire (second wrangler in 1839) provided a similar establishment, the Cavendish Laboratory However, while the Clarendon had Clifton, the Cavendish had the second wrangler of 1854, James Clerk Maxwell (1871-1879), and the senior wrangler of 1865, Lord Rayleigh (1879-1884), and the second wrangler of 1880, J J. Thomson (1884-1919) Maxwell, Rayleigh, and Thomson made the Cavendish into perhaps the world leader in experimental physics, the Clarendon languished

The contrast between developments at the Clarendon and those at the Cavendish epitomizes the need to consider human beings as well as numbers It also manifests a difference in tenor between Oxford and Cambridge that historians sense as much as footnote.[29] Perhaps this is why historians who have found a basic theme for British intellectual history in the same parameters and the same source — the thoughts of Samuel Taylor Coleridge — not only employ different nomenclature but also different emphases depending on which of the two universities they spotlight

Ben Knights writes about Coleridge's concept of a clerisy as an amalgamation of the gentry and the wealthy middle classes into a national elite rooted in Christianity and the eternal principles of all knowledge, the mathematical and natural sciences, as well as the humanities. The clerisy would maintain the noumenon against the phenomena, unified knowledge against technical expertise and the fragmentation of disciplines Being neither clergymen nor men of letters but endowed with the attributes of both, they would act as the philosopher-intermediaries between people, between people and the transcendent, and between "true" culture and society The clerisy would form and preserve the good and uphold it as an ideal at which

[28] J L Heilbron, *H G J Moseley The Life and Letters of an English Physicist, 1887-1915* (Berkeley University of California Press, 1974), p 34

[29] G W Roderick and M D Stephens, "Scientific Studies at Oxford and Cambridge, 1850-1914," *British Journal of Educational Studies*, 25 (1976), 49-66, especially p 57, J B Morell, "Science and the Universities," *History of Science*, 15 (1977), 145-152, especially p 150, Gerald L Geison, *Michael Foster and the Cambridge School of Physiology* (Princeton. Princeton University Press, 1978), pp 81-100

society — always imperfect — might aim and thereby improve [30] In tracing the idea of a clerisy, Knights deals almost exclusively with literary figures and relegates mathematics and science to the periphery, and when considering Oxbridge he centers on Oxonians much more than Cantabs

A contrast is found in the work of Susan Faye Cannon, who has directed historians to the "Cambridge Network," an amendment of Thomas Arnold's contention that there was a "Cambridge Movement" stemming from Coleridge For Cannon, an individual need not have been a Cantab to be a member of the Cambridge Network, rather, he was a member if and only if he held to the "truth complex" in which truth in literature, science, and religion was one, as was the means of ascertaining that truth. Adherence to the "truth complex" held together a "loose convergence" of like-minded individuals who in the first half of the nineteenth century transformed Cambridge and created what is completely alien to the twentieth century, a unified intellectual world-view [31] Cannon focuses on Cambridge more than Oxford, science more than literature, and there is a different flavor to the Cambridge Network It is less ethereal, more down to earth, one could almost say, more vulgar, than Knights' clerisy. Cannon's personnel were natural theologians rather than gnostics, searchers after the phenomena more than the guardians of the noumenon, men in society rather than men above society Even in literature, Cannon's circle was concerned with the nitty-gritty of historical methodology and philological criticism more than with philosophical contemplation Nevertheless, a segment of Cannon's network has been cited as a "scientific clerisy," that group which "came closest to incarnating the idea of a clerisy" and formed the core of the "Gentlemen of Science" which incorporated non-scientist gentry as well as scientists into the leadership of the British Association for the Advancement of Science [32]

Knights' clerisy and Cannon's network constitute frameworks in which to fix the wranglers. Conversely, since the wranglers were not selected on the basis of adherence to the idea of a clerisy or the truth complex, they make up a random sample relative to the two concepts and, therefore, a test of how widely each of the two ideals was en-

[30] Ben Knights, *The Idea of the Clerisy in the Nineteenth Century* (Cambridge Cambridge University Press, 1978), especially pp 37-71 See also David Newsome, *Godliness and Good Learning Four Studies on a Victorian Ideal* (London Murray, 1961)

[31] Susan Faye Cannon, *Science in Culture The Early Victorian Period* (New York Dawson and Science History Publications, 1978), pp 29-71, and 263-287

[32] Jack Morrell and Arnold Thackray, *Gentlemen of Science Early Years of the British Association for the Advancement of Science* (Oxford Clarendon Press, 1981), especially pp 21-29, 224-246, p 21 for the quotation

grained among Cambridge men. The computer-generated data do not provide a very fine analysis. About all that can be said on the basis of it is that the wranglers' social origins might fit them for either Knights' group or Cannon's, and assuming that the clerisy would have commonly defined occupations, the wranglers might fit either classification vocationally Investigation at a deeper level is necessary for a meaningful assessment

The wranglers in church-academe would appear most likely to hold to the idea of a clerisy or the truth complex Certainly their religious roots went to the core of their being In desperate need of an academic position eight years after he graduated senior wrangler in 1841, George Gabriel Stokes refused to be a candidate for a desirable chair at the University of Glasgow because Glasgow demanded a testimonial which he believed would compromise his Anglican faith Nothing could convince Stokes to compromise, not even the persistent urgings and arguments to assuage Stokes' conscience by his friend and fellow physicist, the second wrangler of 1845, William Thomson (later Lord Kelvin), already ensconced at Glasgow as Professor of Natural Philosophy [33]

Religious commitment marked the wranglers in church-academe, and, as we shall see, marked them in a way that makes Cannon's description more appropriate for them than Knights'. Even though they tended to be both clergymen and men of letters, they were not something else Indeed, they were professional men in society rather than elites removed from society, natural theologians rather than philosophical theologians, and researchers rather than synthesizers of inherited knowledge. James Maurice Wilson, senior wrangler in 1859, who became a clergyman, science teacher and researcher, proclaimed that when a boy learns science he learns the path to truth and "feels that he is in the presence of a Power and Wisdom that as far transcends the power and wisdom of man as the universe surpasses a watch in magnitude "[34] Charles Pritchard, the fourth wrangler of 1830, was the Headmaster of Clapham Grammar School (1832 to 1864), Hulsean Lecturer (1867) and Select Preacher at Cambridge (1869 and 1881), and Professor of Astronomy at Oxford (1870 to 1893) He became a pioneer in the photographic measurement of stellar

[33] Stokes to Thomson, 12, 16, 19, and 22 February 1849, *Kelvin Collection*, Cambridge University Library, Add Mss 7342, S340-S343

[34] Saffin, *Science, Religion, and Education*, p 214 Note the phrase "in the presence of " Adherents to the truth complex were theists rather than deists In the remainder of this essay, biographical data are taken from Venn, *Alumni Cantabrigienses*, the *DNB*, or Charles C Gillispie, *Dictionary of Scientific Biography* (New York Scribner, 1970-1976), unless otherwise specified

parallax, the author of numerous articles and of an advanced textbook on statistical couples and the figure of the earth, President of the Royal Astronomical Society (1886), and the recipient of the Royal Society of London's Royal Medal (1892) He also preached the compatibility of science and religion before the British Association for the Advancement of Science in 1869 and published several works on the subject [35] "Providence," he said, "made me an astronomer, but gave me the heart of a divine "[36] Similarly, the greatest British mathematical physicists of the age, Stokes, Thomson, and Maxwell, perceived science as the path to truth, and truth the path to religious belief [37]

As the wrangler-physicists held to the truth complex, so did wrangler-clergymen like Thomas Rawson Birks, second wrangler in 1834, Harvey Goodwin, second wrangler in 1844, and John William Colenso, second wrangler in 1836 Birks, the son of a dissenter, became an Anglican evangelical clergyman and Knightbridge Professor of Moral Philosophy at Cambridge (1872-1883) As a student, he wrote an essay which formed the basis for a lecture he delivered before the University In it, Birks argued that there existed truths in moral philosophy as certain as those in mathematical sciences, while stressing the "undemonstrated and underived" status of the foundations of all human knowledge [38] Birks's presentation dazzled his college tutor, William Whewell, and won him the chief English declamation prize as well as acclaim within and without the University [39] After graduation,

[35] Charles Pritchard, *The Testimony of Science to the Continuity of the Divine Thought of Man A Sermon Preached in Exeter at the Meeting of the British Association for 1869* (London, 1869), in *College Pamphlets*, 1478, *Modern Science and Natural Religion* (Oxford Oxford University Press, 1874), in *College Pamphlets*, 1599, and *Occasional Thoughts of an Astronomer on Nature and Revelation* (London Murray, 1889)

[36] *Dictionary of National Biography*

[37] Joe D Burchfield, *Lord Kelvin and the Age of the Earth* (New York Science History Publications, 1975), pp 48ff, Crosbie Smith, "Natural Philosophy and Thermodynamics William Thomson and the Dynamical Theory of Heat," *British Journal for the History of Science*, 9 (1976), 293-319, especially pp 303-304, William Thomson, *Mathematical and Physical Papers* (Cambridge Cambridge University Press, 1881-1911), pp 2, 38, P H Heimann, "Molecular Forces, Statistical Forces, Statistical Representation, and Maxwell's Demon," *Studies in the History and Philosophy of Science*, 1 (1970), 203, Karl Pearson, "Old Tripos Days at Cambridge as Seen from Another Viewpoint," *Mathematical Gazette*, 20 (1936), 32, Joseph Larmor, ed *Memoir and Scientific Correspondence of the Late Sir George Gabriel Stokes*, 2 vols (1907, rpt ed , New York Johnson Reprints, 1971), I, 76-90, Stokes Collection, Cambridge University Library, Add Mss 7656, W99-106

[38] Thomas Rawson Birks, *Oration on the Analogy of Mathematical and Moral Certainty Delivered in the Trinity College Chapel, December 16, 1833* (Cambridge Cambridge University Press, 1834), Cambridge University Library, Cam d 500 4[6]

[39] Whewell to J C Hare, Christmas Day 1833, to his sister, 14 January, 31 March 1834, and to William Wordsworth, 14 May [n y], Whewell Papers, Trinity College Library, Cambridge University, Add Mss c 215[29], 191[130],[193], and 91[10 7]

he updated and included the lecture in several publications [40] He also applied probability theory to ascertain the reliability of scriptural manuscripts of different ages [41] Goodwin, who would become a most successful mathematics textbook author and a founder of the London Workingmen's College, in 1845 argued the validity of using geometric lines to represent mechanical forces before the Cambridge Philosophical Society He reminded his audience that the truths of both geometry and mechanics converged in the absolute intuition of the Divine Mind, and, therefore, they should accept his premise even if they doubted his mathematical demonstration of it [42] As Bishop of Carlisle, in 1883, he still maintained the holy and holistic nature of science and religion [43] Colenso, who became Bishop of Natal, published numerous works ranging from mathematics textbooks to Zulu grammar books and a Zulu-English dictionary. Between 1862 and 1879, he questioned the chronology of the Bible, the immediacy of its authorship, and its descriptive authenticity within seven volumes of biblical criticism [44] The Bishop of Capetown decided to remove Colenso from his Bishopric, but the Crown overturned that decision. Vindicated, Colenso published a demonstration of the compatibility of historical criticism and spiritual faith.[45] However, within a community of independent thinkers, Colenso had to be answered, and who better to answer than fellow wranglers? Birks, Goodwin, and Pritchard criticized Colenso's criticisms [46]

IV

The church-academe wranglers definitely fit both the letter and the spirit of Cannon's terminology Moreover, they formed a network,

[40] Thomas Rawson Birks, *The Treasures of Wisdom or, Thoughts on the Connection between Natural Science and Revealed Truth* (London Seely, Jackson, and Holliday, 1855), *First Principles of Moral Science, a Course of Lectures Delivered in the University of Cambridge* (London Macmillan, 1873), and *Modern Physical Fatalism and the Doctrine of Evolution, Including an Examination of Mr H Spencer's First Principles* (London Macmillan, 1876)

[41] Thomas Rawson Birks, *Essay on the Right Estimation of Manuscript Evidence in the New Testament* (London Macmillan, 1878)

[42] Harvey Goodwin, 'On the Connexion Between the Sciences of Mechanics and Geometry,' Cambridge Philosophical Society, *Transactions*, 8 (1859), 269-277

[43] Harvey Goodwin, *Walks in the Region of Science and Faith* (London J Murray, 1883)

[44] John William Colenso, *The Pentateuch and Book of Joshua Critically Examined*, 7 vols (London Longmans, Green, and Co , 1863-1879)

[45] John William Colenso, *Natal Sermons* (London N Trubner & Co , 1866)

[46] Thomas Rawson Birks, *The Exodus of Israel Its Difficulties Examined and Its Truth Confirmed* (London Religious Tract Society, 1863), Harvey Goodwin, *Essays on the Pentateuch* (Cambridge Deighton, Bell, 1867), Charles Pritchard, *Vindicae Mosaica* (London J Murray, 1863)

one that centered at Cambridge and to a much lesser degree, at Oxford At their *alma mater* wranglers held seventy college tutorships and fifteen professorships (eight in the mathematical sciences, three in law, and one each in moral philosophy, religion, political economy, and medicine). They also filled fifty-one administrative posts, among them fourteen college headships. At Oxford they held eleven positions (five professorships and two lectureships in mathematical sciences, one geology professorship, one lectureship in religion, and two administrative offices). They also provided Oxford with active astronomers in the personages of Robert Main, sixth wrangler in 1834, and Edward James Stone, fifth wrangler in 1859 Main observed and published first as the Chief Assistant at the Royal Observatory, Greenwich (1835 to 1860) and then as Radcliffe Observer at Oxford from 1860 to his death in 1878. Stone succeeded Main at Greenwich (1860 to 1870) and as Radcliffe Observer (1879 to 1897) He was also Astronomer Royal at the Cape from 1870 to 1879, President of the Royal Astronomical Society (1882 to 1884) and a recipient of its Gold Medal

The wrangler network did not end with the traditional seats of English learning, and it was not as Cannon's network, a loose convergence of individuals, indeed, it was an extensive, institutionalized reticulation of active teacher-scholars. At the University of Durham, created in the image of the two ancient universities, two wranglers became mathematics lecturers In Scotland, they held three mathematics professorships and three administrative posts at the University of Glasgow, three mathematics professorships at the University of St Andrews, two at the University of Edinburgh, one at King's College, Aberdeen and one at Marischal College, Aberdeen Still others filled positions at military schools six professorships at both Woolwich and Sandhurst, one at the Royal Naval College, Portsmouth, a lectureship in geology at the School of Military Engineering, Chatham, administrative offices at the Royal School of Naval Architecture and the School of Naval Construction, and a lectureship in religion and an administrative office at Cheltenham, the preparatory school for the military academies Philip Kelland, the senior wrangler of 1834 and Professor of Mathematics at the University of Edinburgh (1838 to 1879), researched and published while introducing Cambridge mathematics to Edinburgh students at large and the future Lord Kelvin specifically, aided by the mechanics textbook of Richard Potter, sixth wrangler in 1838 [47] As Professor of Mathematics at Woolwich fron

[47] Becher, "William Whewell and Cambridge Mathematics," p 47

1844 until death cut short his career in 1855, Matthew O'Brien, third wrangler in 1838, having previously published one of the most advanced Cambridge calculus textbooks while at Cambridge as a tutor and examiner for the Tripos, produced an advanced textbook on plane geometry and a treatise on mathematical geography [48] Joseph Woolley, third wrangler in 1840, after a career in the Church until 1848, became Principal of the School of Naval Construction, Portsmouth from 1848 to 1853, Admiralty Inspector of Schools from 1859 to 1864, one of the founders of the Institution of Naval Architects in 1860, Inspector-General and Director of Studies at the Royal Naval College, Greenwich as well as Dean of the Royal School of Naval Architecture from 1864 to 1873, editor of *Naval Science* (1874 to 1875), and the author of articles on naval architecture.

These few examples could be multiplied, but they suffice to illustrate the concreteness of the wrangler network and that the practical and specialized professional activities of the wranglers within it do not fit neatly into the idea of a clerisy or even that of gentlemen of science Even more, they do not fit neatly with the image of Cambridge men in general, at least not the image delineated by historians The Scottish universities and the military schools had "modern" sides to their curricula, that is, they included science and practical mathematics The same was true of new "red-brick" universities, and some other schools, usually located in urban-industrial areas Historians often perceive the content and objectives of an Oxford or Cambridge liberal education as irrelevant to this modern element, and, consequently, see a conflict between the two older universities and the new schools Typical is the statement of Michael Sanderson· "Against them [Oxford and Cambridge] were ranged the Civic Universities and London, avowedly vocational, many suspicious of and hostile to the older idea of a liberal education, catering for a social class without the background to thrive in the Church, Civil Service or law and accordingly oriented towards science and technology."[49]

Sanderson's indictment, however valid for Oxbridge as a whole, should be tempered in appraising the wranglers. As we have seen, the

[48] Matthew O'Brien, *An Elementary Treatise on the Differential Calculus in which the Methods of Limits is Exclusively Made Use of* (Cambridge J and J J Deighton, 1842), *A Treatise on Plane Co-ordinate Geometry* (Cambridge Deightons, 1844), and "Mathematical Geography," in C G Nicolay, *A Manual of Geographical Science, Mathematical, Physical, Historical and Descriptive* (London J W Parker, 1852-1859)

[49] Michael Sanderson, *The Universities in the Nineteenth Century* (London Routledge and Keagan Paul, 1975), pp 4-5 See also Rothblatt, *Revolution of the Dons*, p 267, and *Tradition and Change*, pp 39, 139-141, McPherson, *Theory of Higher Education*, pp vii-viii, 29-38, 63-64, Gordon W Roderick and Michael D Stephens, *Scientific and Technical Education in Nineteenth Century England* (New York Barnes and Noble, 1972), pp 11-13, 26-44

largest number of wranglers came from the London colleges, and many wranglers took "modern" positions and actively pursued "modern" subjects. In addition, the wranglers infiltrated the red-brick schools themselves. At University College, London and the University of London, they filled five administrative offices, four professorships in mathematics, and one professorship in political economy They occupied one administrative office, one lectureship in mathematics, and five professorships at King's College, London, four in mathematics and one in medicine They held four professorships in mathematics at East India Colleges, three at Owen's College, Manchester, three at Queen's College, Belfast, two at Gresham College, London, one at Queen's College, Birmingham, and one at Royal School of Mines, two mathematics lectureships at Liverpool College, and one at the College of Civil Engineering, Putnam, and at Owen's College, Birmingham; a geology professorship at Leeds College; an administrative office and a Professorship of Astronomy at Gresham College, and administrative positions at the College of Civil Engineering, Putnam, and the East India College, Addiscombe

As wranglers elsewhere, these wranglers at the "progressive" institutions partook fully in professional activities, activities embedded in the social fabric of Britain Alexander Henry Green, sixth wrangler in 1855, worked on the Ordnance (Geology) Survey from 1861 to 1875 in Derbyshire and South Yorkshire, was Professor of Geology at Leeds College from 1875 to 1888, and, finally, Professor of Geology at Oxford from 1888 to 1896, during which time (1890) he was President of the Geological Section of the British Association for the Advancement of Science. John W L. Heaviside, second wrangler in 1830, was Canon of Norwich from 1860 until his death in 1897 and mathematics tutor to Prince Arthur, later Duke of Connaught; he also was Professor of Natural Philosophy at the East India College, Haileybury from 1836 to 1860, examiner for the University of London in 1844 and for the Council of Military Education in 1858, and Chairman of the Norwich Grammar and Commercial Schools' Schoolboard. Benjamin T Moore, eighth wrangler in 1856, left his position as Mathematical Master at Harrow (1856 to 1858) to become Professor of Mathematics at Sandhurst (1859 to 1864) and Professor of Civil Engineering and Applied Mechanics at University College, London (1868 to 1871). John Francis Twisden, seventh wrangler in 1848, was Perpetual Curate of Minley, Northamptonshire, from 1880 to 1888, and succeeded in establishing a family claim to a Baronetcy in 1909. Nevertheless, he was also Professor of Mathematics at Sandhurst from 1858 to 1885, and

examiner for the Board of Education and the Department of Science and Arts from 1869 to 1914

Twisden was one of eleven wranglers who became government administrators of education Another was Walter Bailey, second wrangler in 1860, an inspector of schools from 1870 to 1890 and a member of the council of the University of London from 1893 to 1907 and of the University College Committee from 1907 to 1915. Bailey was an advocate of scientific education; he also invented a Z-phase electric motor and an integrating anemometer, published scientific articles, and was Vice-President of the Physical Society of London from 1890 to 1895 Even wranglers at traditional institutions were often engaged in socially useful activities Wilson, who voiced his approval of the truth complex, was Assistant Master at Rugby from 1859 to 1879 and Headmaster of Clifton from 1879 to 1890 He then took up a Church career in earnest. Vicar of Rochdale and Archdeacon of Manchester from 1890 to 1905, Canon of Worcester (1905-1926), and theology lecturer at Cambridge On the surface, Wilson was a typical "irrelevant" Oxbridge-public school-liberal education elitist Yet he introduced modern mathematics and physics at Rugby (in the cloakroom of the Town Hall because no facilities were available at the school), became a primary advocate of science teaching in the schools and Cambridge, did some original scientific research, and, in 1921, at age 85, became President of the Mathematical Association.[50] Likewise, Robert Baldwin Hayward, fourth wrangler in 1850, tried to upgrade mathematics teaching at Harrow while Mathematics Master there from 1859 to 1893 and was President of the Association for the Improvement of Geometrical Teaching from 1879 to 1889.

The wranglers did not disdain the new red-brick universities or the movement toward scientific education, which leads into a broader controversy When historians differentiate between the ancient universities and the new schools, it is almost always within the "decline of England" debate which centers on the question of why England failed to fulfill the promise of the industrial revolution which it had begun In this context, Cambridge is always linked to Oxford and the public schools as the educational component of the effete, snobbish, backward-looking, gentrified establishment hostile to new business-industrial enterprise, or as it was succinctly articulated most recently by Martin J Weiner, "As with the public schools, very few undergraduates came from business backgrounds Oxford and Cambridge,

[50] Saffin, *Science, Religion, and Education*, pp 213-215, Simon and Bradley, *Victorian Public School*, pp 103-112, Archer, *Secondary Education*, pp 141-143

even more than the public schools, were precincts for the sons of gentry, clergy, and more distinguished professions a fusion of aristocratic and professional values, stood self-consciously in opposition to the spirit of Victorian business and industry It exalted a dual ideal of cultivation and service against philistine profit seeking "[51]

As in deciding between "clerisy" and "network," impressionistic overtones rather than hard data entitle all to their opinions The arguments here are not meant to challenge interpretations in their generality, however, but only to question how well they apply to the wranglers. Both the computer-generated data about the wranglers and the short biographical expositions given above should cause some hesitation in uncritically including the wranglers among the obstructionists As we have seen, they came from a broader social background than Cambridge students in general and students at the public schools, and though a large percentage of them came from London — supposedly the bastion of the economically and culturally old-fashioned — many came from the north, the stronghold of newer, less affluent, forward-looking industrialists [52] True, the middle-class wranglers, regardles of their geographic origins, deserted their heritage for church-academe and the law, but this was their choice and perhaps that of their fathers rather than a function of their education

Mathematics at Cambridge was oriented toward the applied, and engineering was not completely neglected In fact, early in the nineteenth century, the Jacksonian Professor of Natural and Experimental Philosophy established at Cambridge "the first real course on mechanical engineering to be given in any British University," and the Professor of Chemistry delivered up-to-date experimental lectures [53] Wranglers could have entered business enterprises well-equipped to improve them, as illustrated by the few who did As a lighthouse engineer and head of Chance Brothers, a glass manufacturing firm near Birmingham, James Timmins Chance, seventh wrangler in 1838, made improvements in *dioptric apparati* for lighthouses based upon experiments made in conjunction with Michael Faraday. William Austin, grandson of the economist David Ricardo,

[51] Martin J Weiner, *English Culture and the Decline of the Industrial Spirit, 1850-1980* (Cambridge Cambridge University Press, 1981), pp 22-23

[52] W D Rubinstein, "Wealth, Elites and Class Structure of Modern Britain," *Past and Present*, no 76 (1977), 99-126, especially pp 106-108, 112-117, and "The Victorian Middle Classes Wealth, Occupation and Geography," *Economic History Review*, series 2, 30 (1977), 602-623

[53] T J N Hilkin, *Engineering at Cambridge University, 1783-1965* (Cambridge Cambridge University Press, 1967), p 42, Gerrylyn K Roberts, "The Liberally-Educated Chemist Chemistry in the Cambridge Natural Sciences Tripos, 1851-1914," *Historical Studies in the Physical Sciences*, 2 (1980), 157-183, especially pp 159-162

friend of Richard Cobden, and eighth wrangler in 1842, was an advocate for construction of the Metropolitan Railway, became Chairman of both the Metropolitan District Railway and the Metropolitan and St John's Railway, made inventions and technical innovations, and published a book on bimetallism Allan Duncan Stuart, ninth wrangler in 1853, became a Justice of the Peace in Perth, but also was a consulting engineer in Edinburgh from 1861 to 1881 and Head of the London Staff during the building of the Firth of Forth Bridge. These men possessed what marked the Cambridge engineer from the run-of-the-mill English engineer, that is, mathematical training, a circumstance noted by John Henry Pratt, the third wrangler of 1833, who while Archdeacon of Calcutta (1850 to 1871) undertook studies in geophysics [54]

"The doctrine that university education is a way of escape from life, and not a preparation for it,"[55] does not somehow seem *a propos* for the wranglers. More legitimate might be preparation for a better life as perceived by the wranglers themselves, an assessment confirmed also by the large block of wranglers who entered the law For those wranglers unwilling or unenthusiastic about taking holy orders, the law evidently provided an escape Only two of the wrangler-lawyers took steps toward church officialdom. One, Gerard Brown Finch, the senior wrangler of 1857, a Barrister at Lincoln's Inn and compiler of the leading cases on the law of contracts, after returning to Cambridge to teach law was ordained Deacon — thirty-one years after his graduation, and then he did not proceed to the priesthood The other, Sylvester Joseph Hunter, the son of a Presbyterian minister and eighth wrangler in 1852, became a Roman Catholic in 1857 (unique in itself) and joined the Society of Jesus in 1861. None of the other wrangler-lawyers were ordained, and the wranglers who refused degrees on religious grounds became lawyers William Aldam, fourth wrangler in 1836 and the son of a Quaker gentry father, was called to the bar in 1839 and culminated a rather gentlemanly career as Chairman of the West Riding Quarter Sessions. Jew and Fellow Commoner, Benjamin

[54] Pratt to Stokes, 8 July 1861, Stokes Collection, Cambridge University Library, Add Mss 7656, P610, Henry Pratt, ' On the Attraction of the Himalaya Mountains and of the Elevated Regions Beyond Them upon the Plumb-line in India," Royal Society of London, *Philosophical Transactions*, 144 (1854), 53-100, "On the Effect of Local Attraction upon the Plumb-line at Stations on the English Arc of the Meridian, Between Dunnose and Burleigh Moor, and a Method of Computing Its Amount," *Philosophical Transactions*, 146 (1856), 31-52, and "Modification by the Compensating Effect of a Deficiency of Matter Below the Mountain Mass," *Philosophical Transactions*, 144 (1859), 745-778

[55] A J P. Taylor, as quoted by Weiner, *English Culture*, p 133

Cohen (fifth wrangler in 1853), pursued a very successful career without forsaking his religion In addition to becoming President of the Jewish Board of Deputies, he became Queen's Counsel (1874), a Bencher (1875), Judge of Cinque Ports (1874-1914), M P. for Southwark (1880-1887), Counsel to the Secretary of State for India (1893-1914), Chairman of the Bar Council (1903), Counsel for Great Britain at the Venezuela arbitration at the Hague (1903), and a Privy Councilor (1905). Even though he did not forsake his religion, neither did he turn his back on his university When the qualification oath (or the equivalent affirmation or declaration allowed from 1837) for a degree was abolished, he accepted a B.A (1858) and an M.A (1879) and served as University Counsel from 1879-1914 (in succession to the senior wrangler of 1844, George Wingman Hemming). The other Jew among the wranglers, James Joseph Sylvester, the second wrangler of 1837, who became one of the outstanding mathematicians of the nineteenth century and Professor of Natural Philosophy at University College, London (1837-1841), Professor of Mathematics at the University of Virginia (1841-1845), at Woolwich (1855-1870) and at the Johns Hopkins University (1877-1883), was called to the bar in 1850 while working in a firm of actuaries (1845-1853). Like Cohen, he returned to Cambridge for a degree (B.A., 1872); he also spent the last years of his life at Oxford as Savilian Professor of Geometry (1883-1897)

The two Jews retained their ties to academe; other lawyers followed suit The lawyers avoided ordination but did not forsake their university or academic activity. Arthur Cayley, the greatest pure mathematician Cambridge produced in the first half of the nineteenth century, graduated senior wrangler in 1842, was a Trinity tutor from 1843 to 1846, and then practiced law from 1849 to 1863. As a lawyer he vigorously pursued mathematics, and in 1863 he returned to Cambridge as Sadlerian Professor of Pure Mathematics, a position in which he advanced both mathematics and university reform until his death in 1895 Likewise, John Westlake was called to the bar in 1854 after graduating sixth wrangler in 1850 He became Q.C. (1874), a Bencher (1875), M P for the Romford Division of Essex (1885-1886), and a Member of the Hague International Court of Arbitration (1900-1906), he also was, along with Harvey Goodwin, one of the founders of the London Working Men's College (1854), President of the Jurisprudence Department of the National Association for Promotion of Social Science (1884), Whewell Professor of International Law at Cambridge (1888 to 1908), and the author of a pioneering and influen-

tial book on international law (1858) [56] In Scotland, Archibald Smith, senior wrangler of 1836, became an eminent real property lawyer, made practical and valuable contributions to research on compass deviations on ships, published mathematical articles, and along with Duncan Farquharson Gregory, fifth wrangler in 1837 and one of those unfortunate men whose brilliant future was extinguished by an early death, co-founded the *Cambridge Mathematical Journal*, the first truly professional mathematics journal in Britain And as a final example, Henry Fawcett, seventh wrangler in 1856, enjoyed a long career in Parliament (1865 to 1884), where he was a strong proponent of the 1867 Reform Bill specifically and proportional representation generally, an advocate of women's rights (his daughter Philippa embarrassed the men by being placed above the senior wrangler in 1890), and a Privy Councilor (1880) He also was Professor of Political Economy at Cambridge from 1863 to his death in 1884 Obviously, these men researched and taught In fact one might write about law-academe as an analogue to church-academe

The wrangler-lawyers' continued interest in research and teaching did not prevent them from making a strong practical impact on the British legal-political system A summary of their successes and their contributions is provided by raw data, among the wrangler-lawyers are found no less than thirteen Q C.s (and one K C), fifteen Benchers, ten M P.s (some of the ten being elected more than once), eight Knighthoods, six Privy Councilors, five Judges of County Courts, three Lord Justices of Appeal, three Solicitors-General, two Financial Secretaries of the Treasury, a Baron of the Exchequer, a Post-Master General, a Judge of the City of London and Central Criminal Courts, a Judge of the Chancery Division of the High Court, an Official Referee of the Supreme Court, a Commissioner of Assizes for South Wales, an Under-Secretary of State for the Home Department, an Under-Secretary for India, an Attorney-General of Trinidad, West Indies, a Judge of the High Court of Bengal, Chief Justices of the Leeward Islands, of Ceylon, of the Ionian Islands, and of Bombay, and a Judge of the Supreme Court of Victoria, Australia.

The wranglers practiced, and they researched, published, and taught Were they less "productive" than they would have been in industry? Would it have been better if more wranglers had been solicitors and thus enjoyed the esteem of present-day historians and a debased occupational status because they would have received "money

[56] Richard A. Cosgrove, *The Rule of Law Albert Venn Dicey, Victorian Jurist* (Chapel Hill University of North Carolina Press, 1980), p 166

directly from their clients"?[57] Should more of the wranglers have failed to receive a call to the bar as one did — and become wine merchants as that one did? The wranglers were an elite and as such they sought elite careers In these careers, they were productive Did they serve Cambridge or England badly?

Perhaps the arguments put forth in this essay can be suggestive when considering Cambridge as a whole, only queries when discussing Oxbridge and the overall decline-of-England debate It may be that the data can be turned against the general drift presented here. The Mathematics Tripos provided an aristocracy of talent, an aristocracy which preferred careers in the church, academe, and law rather than business and industry Even the middle-class sons tended to turn their backs on their heritage This might be considered a misallocation of resources, but it is doubtful that British society would have done without the church, or could have done as well without the human flexibility and tensile strength that allowed British church, educational, and political institutions to stretch rather than break The wranglers reinforced this flexibility and strength, perhaps because for most of them there was little or no intrinsic linkage between their undergraduate mathematical achievement and their post-graduate goals They did not pursue a narrow discipline as an end in itself or become dedicated to narrowly defined professional ideals and ends abstracted from society Instead of forming an alienated intelligentsia, the best and the brightest, having proved their worth on the Tripos, became pillars of the establishment which had selected them, educated them, and provided them with opportunity [58] The wranglers formed the academic analogue to the Victorian political adjustment in which the old elite absorbed the vanguard of the middle classes.

The stultifying effect of such an adjustment can be as frustrating for present-day critics of Cambridge within the decline-of-England debate as it was for outsiders in the nineteenth century. In the wranglers, however, Cambridge educated educators, and, at least from this author's viewpoint, it is not clear that the wrangler-educators manifest the "failure" of Cambridge, nor is it clear that they are responsible in a negative sense because the newer schools "did not

[57] T H S Escott (1844-1924), as quoted in Wiener, *English Culture*, p 15

[58] For discussions of similar vein, in different context, see T W Heyck, "From Men of Letters to Intellectuals The Transformation of Intellectual Life in Nineteenth-Century England," *Journal of British Studies*, 20 (1980), 158-183, Noel Annan, "The Intellectual Aristocracy," in J H Plumb, ed , *Studies in Social History A Tribute to G M Trevelyan* (Freeport, New York Books for Libraries Press, 1969), pp 243-287, Peter Allen, *The Cambridge Apostles The Early Years* (Cambridge Cambridge University Press, 1978), especially pp 198-218

develop distinctive programs or clients of their own," but rather fell under Oxbridge's "cultural dominance" (Ringer, "The Education of Elites," p 169). Moreover, the direction taken by the British schools appears to differ little from that taken by similar institutions in the United States, often held up as the antithesis to the decline of English education (Weiner, *English Culture*, p 24) Students pass through community colleges to the universities, and community colleges strive to become academically "respectable" rather than technical schools Land grant colleges, teachers' colleges and others strive to become universities, and provincial universities and their professors emulate prestigious universities in hopes of becoming "mature " Prestige lies in producing theoretical physicists rather than applied mathematicians, theologians rather than ministers, and historians rather than teachers of history. In this context, let alone the context of nineteenth-century English society and the position of Cambridge in that society, it is difficult to find the wranglers socially irrelevant or to see in their careers a misallocation of resources Their choice of careers, not much different from that of present-day historians writing about them, is understandable: careers in industry were much less attractive in their time than ours [59]

Of course, Cambridge did not anticipate the needs of the second industrial revolution any more than it did the first. But did it do so badly when compared to how many universities of the 1950s paid heed to the forecasts of the post-industrial, high technology, computer-oriented future in which they now find themselves? To answer demands close historical analysis Within the history of science, Cambridge wranglers staffed the Professorship of Natural Philosophy and that in mathematics (from its inception) at Owen's College, Manchester, and also two wranglers became Professors of Mathematics at the University of Toronto J. J. Thomson studied at Owen's College, Manchester, under a senior wrangler before coming up to Cambridge where he studied under Cayley, Stokes (Lucasian Professor of Mathematics from 1849 to 1903), and John Couch Adams (senior wrangler of 1843, co-discoverer of Neptune, and Lowndean Professor of Astronomy at Cambridge from 1861 to 1892) as well as under the staff of the Cavendish, all of whom had come through the Mathematics Tripos. Owen's College, the McGill Laboratory at Toronto, and the Cavendish formed a triad of excellence through which passed numerous outstanding physicists, including Ernest Rutherford, who

[59] For a description of working conditions in the craft of industrial engineering at the time, see "On Industrial and Scientific Engineering," *Journal of the Society of Arts*, (13 December 1867), 57-70

studied and or worked at all three before becoming the first non-wrangler Cavendish Professor as the successor to Thomson [60] At a level beneath the great names of physics, there is a story to be told.

To the historian of science, the substructure provided by the wrangler-physicists is pertinent; unfortunately, the history of the Cambridge Apostles and its link to the Bloomsbury Group, a primary focus for historians of literature, is not It is difficult for the historian of science to accept the list of Apostles as including "most of the great Cambridge names of the nineteenth century "[61] Among the Apostles we find the names of only seven of the wranglers, and though one of those names is Maxwell, we do not find the names Adams, Stokes, Kelvin, Cayley, Sylvester, and George Green, fourth wrangler in 1837, who was recognized as a brilliant mathematician and physicist even before he came up to Cambridge (For the list of Apostles, see Levy, Moore, pp 300-311) Of course, if an historian of science made up a list of the great Cambridge men of the nineteenth century, it would appear just as vacuous to the historian of literature

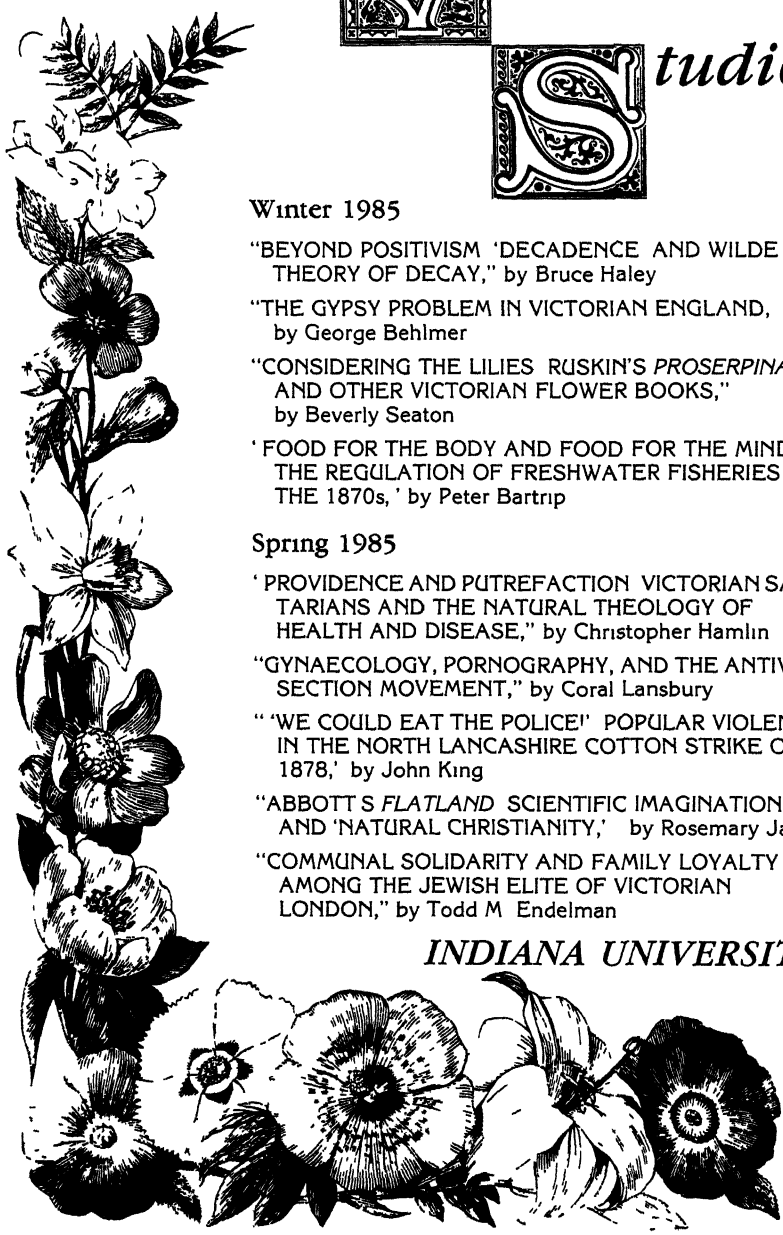
But is there more involved than simply the blinders of modern-day sub-disciplines? After all, the Apostles selected their own Were the wranglers one culture, socially and intellectually, with the classicists and literary figures? How representative of Cambridge were the wranglers? Are the differences in tone between the idea of the clerisy and that of the Cambridge network, between Oxford and Cambridge, between wranglers and Cambridge literary figures, simply impositions of present-day historians with their own special interests, or did they actually exist? And how is all of this related to the decline of England? Questions such as these can be answered only by in-depth historical analysis which encompasses a broader segment of Victorian society than just the great names and brings together the expertise of historians of various specialties Such a gargantuan synthesis might bring into being a unified intellectual community in the 1980s, at least within the discipline of history.

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[60] John William Strutt, Lord Rayleigh, *The Life of Sir J J Thomson O M Sometime Master of Trinity College, Cambridge* (Cambridge Cambridge University Press, 1943), pp 3-11, Cambridge University, Cavendish Laboratory, *A History of the Cavendish Laboratory* (New York, 1910), pp 75-81, David B Wilson, "Experimentalists Among the Mathematicians Physics in the Cambridge Natural Sciences Tripos, 1851-1900," *Historical Studies in the Physical Sciences*, 12 (1982), 325-371, on p 354, A S Eve, *Rutherford, Being the Life and Letters of the Rt Hon Lord Rutherford, O M* (Cambridge Cambridge University Press, 1939), E N Da C Andrade, *Rutherford and the Nature of the Atom* (New York Doubleday, 1964), pp 25-158

[61] Paul Levy, *Moore G E Moore and the Cambridge Apostles* (New York Holt, Reinhart and Winston, 1979), p 2

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INDIANA UNIVERSITY

Margaret Schabas

THE "WORLDLY PHILOSOPHY" OF WILLIAM STANLEY JEVONS*

SINCE THE ENLIGHTENMENT, ECONOMISTS HAVE TRADITIONALLY LOOKED to Newtonian physics as the science to emulate But although the classical economists were clearly aware that their discipline did not match the predictive and explanatory successes of the physical sciences, they did not take specific steps to adopt tools, such as mathematics, that might enhance its credibility as a science On the contrary, those who bothered to address such issues, most notably Adam Smith and John Stuart Mill, simply maintained that economics used precisely the same method as Newtonian physics and was thus already a mature science [1] The many difficulties encountered in the verification of economic hypotheses were attributed to the complexity of the phenomena and not to any defects in the methods used.

In 1871 William Stanley Jevons challenged this complacent attitude by prescribing the extensive mathematization of economic theory "Economics," he announced at the beginning of his *Theory of Political Economy*, "if it is to be a science at all, must be a mathematical science "[2] Although one can find sporadic attempts to apply mathematics to economic theory prior to 1871 — William Whewell is perhaps the best-known example in England — Jevons was the first to insist that economics must necessarily be treated mathematically There is almost no question that Jevons regarded mathematics as *the* means to elevate the scientific status of economics, in direct imitation of the physical sciences His intentions, then, were much the same as

* I wish to thank H Scott Gordon, Samuel Hollander, David A Hollinger, Trevor Levere, and Warren Samuels for many helpful suggestions

[1] For appraisals of Smith's and Mill's views on method, see, respectively, Samuel Hollander, "Adam Smith and the Self-Interest Axiom," *Journal of Law and Economics*, 20 (1977), 133-152, and J K Whitaker, "J S Mill s Methodology," *Journal of Political Economy*, 83 (1975), 1,033-1,050

[2] William Stanley Jevons, *The Theory of Political Economy*, 5th ed (1957, rpt ed , New York Augustus M Kelly, 1965), p 3

those of his classical predecessors. But his conviction that "economics . must be a mathematical science" was a radical departure from previous economic thought and calls for an explanation It is argued here that Jevons's scheme for the mathematization of economic theory was profoundly shaped by his study of contemporaneous developments of the natural sciences, logic, and scientific method, a study which occupied much of his attention during the 1860s and which reached its published form in 1874 as *The Principles of Science* [3]

According to T W Hutchison, Jevons derived the idea of applying mathematics to economic theory from the Benthamite notion of maximizing utility [4] However attractive an explanation this might sound, it does not conform to the facts To be sure, the utility theory of value as cast under utilitarian prescripts played a significant role in Jevons's approach to economics and was in many respects the anchor point for his specific use of algebra. But Jevons's decision to devise a mathematical treatment of economics preceded his commitment to the utility theory of value His eventual promotion of a hedonic approach to the problem of value, moreover, was not particularly innovative As Marian Bowley has shown, and as Jevons himself recognized, the utility theory was well entrenched in the economic literature by the middle of the nineteenth century.[5] The "Jevonian Revolution" constituted not so much a reaction to problems arising within, or to the ideological consequences of, the theory of David Ricardo and J S

[3] William Stanley Jevons, *The Principles of Science*, 2d ed (London Macmillan, 1877) During the 1860s Jevons also published several works on logic which were incorporated into the *Principles* For a list of these, see Harriet A Jevons, ed , *Letters and Journal of W Stanley Jevons* (London Macmillan, 1889)

[4] T W Hutchison, *On Revolutions and Progress in Economic Knowledge* (Cambridge Cambridge University Press, 1978), pp 86-87 Hutchison also attempts to undermine the significance of the mathematics in Jevons's work 'But the development of mathematical formulations could be held to have been secondary rather than primary in 1871 It was not so much a question for Jevons of championing mathematical formulation *a priori* Rather the central significance of the marginal concept and the maximising individual was arrived at first, by Jevons at any rate, and mathematical formulation and the calculus were championed secondarily, as tools for developing and deploying these concepts" (Hutchison, pp 86-87) Hutchison s position does not accord with the extant correspondence of Jevons

[5] Marian Bowley has shown quite convincingly that the only real reform that could have taken place in 1871 was in the area of methodology See Marian Bowley, "The Predecessors of Jevons — The Revolution that Wasn t, ' *Manchester School*, 44 (March 1972), 9-29 R D Collison Black has also promoted this interpretation Jevons "emphasized the importance of the mathematical method Here, rather than in the development of utility theory as such, was the essence of his break with the classical tradition' (R D Collison Black, Jevons, Marginalism and Manchester, ' *Manchester School*, 40 [March 1972], 5) Jevons recognized, as early as 1860, that his 'law of utility has in fact always been assumed by Pol Econ under the more complex form and name of the Law of Supply & Demand (R D Collison Black, gen ed , *Papers and Correspondence of William Stanley Jevons*, 7 vols [London Macmillan Press, 1972-1981], II, 410) Hereafter cited in the text as Jevons, *Papers* Jevons s developed analysis of exchange demonstrated moreover not only "the final equivalence of labour and utility, ' but also "the well-known law, that value is proportional to the cost of production' (Jevons, *Theory*, pp 177, 186)

Mill, as an attempt to reinforce the stature of economics as a true science [6] The primary factor which led Jevons to convert political economy into the "science" of mathematical economics was independent of the subject matter [7]

Commentators have often noted that there must be some important connection between Jevons's work on scientific method and his reformulation of economic theory [8] Although his *Principles of Science* dealt almost exclusively with the natural sciences, Jevons had always insisted, both at the start of the *Principles* and throughout the *Theory*, that the social sciences used precisely the same methods as the physical sciences (Jevons, *Principles*, p xxvii) Indeed, Jevons subscribed to the view, commonplace among Victorian scientists, that "all the sciences meet somewhere No part of knowledge can stand wholly disconnected from other parts of the universe of thought" (Jevons, *Principles*, p 154). It seems reasonable to suppose that Jevons's prolonged study of scientific method had some bearing on his lifelong campaign to render economics a mathematical science But the two attempts made thus far to identify this connection have focused upon the inductive and experimental aspects of Jevons's work in applied economics [9] This paper will identify, for the first time, some of the many links between Jevons's program for mathematical economics and scientific method

I

Born in Liverpool in 1835, Jevons went to study at University College, London, at the age of fifteen. He soon developed a love for the

[6] For representative statements of the internalist position, see Hutchison, *On Revolutions*, chaps 3-4, and Maurice Dobb, Theories of Value and Distribution Since Adam Smith (Cambridge Cambridge University Press, 1973), chap 7

[7] In order to carry out such innovations, it was essential, of course, for an economist to have studied some mathematics first Jevons, however, was by no means the first British economist to have acquired these skills Thomas Malthus, Henry Fawcett, and Jacob Waley, all professors of political economy, held degrees in mathematics Even Mill had studied some calculus at the university level A knowledge of mathematics, while a necessary condition for the transformation under consideration here, was clearly not, at least in nineteenth-century Britain, a sufficient one

[8] See, for example, Philip Henry Wicksteed, *The Common Sense of Political Economy*, Lionel Robbins, ed (London George Routledge & Sons, 1935), II, 809, and R D Collison Black, "Introduction,' W S Jevons, *Theory of Political Economy*, Harmondsworth Penguin, 1970), pp 13-14

[9] According to one study, "the most striking instance of the impact of Jevons s results in scientific method on his economics is to be found in the introduction to his paper on 'The Solar Period and the Price of Corn' " (Barbara MacLennan, Jevons's Philosophy of Science, *Manchester School*, 40 [March 1972], 62-63) The other paper, while acknowledging that Jevons's system of logic must have played a part in his theory of economics, emphasizes the role of statistics and experimentation in Jevons's work on monetary economics and social reform (Wolfe Mays, "Jevons's Conception of Scientific Method, ' *Manchester School*, 30 [September 1962], 223-249)

sciences and subsequently won several prizes in chemistry and botany [10] Rather than complete his degree, however, financial difficulties compelled him to accept a lucrative offer to work as an assayer in the Australian mint During his five-year sojourn in Sydney, Jevons resolved to forgo his ambitions to pursue chemistry and instead make his mark in economics. More important, he decided, even prior to returning to London in 1859 to complete his studies, to develop a mathematical treatment of economics From his first encounters with the literature, specifically the *Wealth of Nations* (1776), it is evident that Jevons discerned the mathematical character of economics To his sister, for example, he wrote in 1858. "You will perceive that *Economy*, scientifically speaking, is a very contracted science; it is in fact a sort of vague mathematics which calculates the causes and effects of man's industry, and shows how it may best be applied" (Jevons, *Papers*, II, 321) And, after much deliberation, he confessed in the following year to his cousin and mentor, the chemist Henry Enfield Roscoe "You know I am yet in a transition state I told you, long since, that I intended exchanging the physical for the moral and logical sciences, in which my *forte* will really be found to lie . I wish especially to become a good mathematician, without which nothing, I am convinced, can be thoroughly done Most of my theories proceed upon a kind of mathematical basis "[11]

For the next three years, Jevons devoted himself to the study of political economy, philosophy, and mathematics. Shortly after completing his Master's degree in the "moral sciences," with the Ricardo Prize and M A Gold Medal in hand, Jevons submitted a paper, "A Brief Account of a General Mathematical Theory of Political Economy," to the 1862 meetings of the British Association Although the paper, quite remarkably, contained all of the major theoretical insights of his later *Theory*, it was at the time "received without a word of interest or belief "[12]

Though somewhat discouraged, Jevons decided to change tactics and establish himself in the field of applied economics The

[10] Jevons actually started at the Junior School of University College before spending two years at the College proper, where he had the good fortune to study with one of the leading mathematicians of the time, Augustus De Morgan Although Jevons tended to deprecate his abilities in the subject, he succeeded in placing fourth on the lower senior-class examination in mathematics in 1853 See R D Collison Black, Jevons, Bentham, and De Morgan, *Economica*, 39 (May 1972), 119-134

[11] Harriet A Jevons, *Letters and Journal*, pp 118-119 Another letter, from his cousin, urged Jevons to continue his work in the physical sciences ' in spite of taking to the Mathematics of Society (Jevons, *Papers*, II, 355)

[12] Jevons, *Papers*, I, 188 The paper was subsequently published in the *Journal of the Statistical Society of London*, 29 (1866) One of the first to correspond with Jevons on the piece, in 1868, was Fleeming Jenkin See Jevons, *Papers*, III, 166-178

strategy proved successful His first work, *A Serious Fall in the Value of Gold Ascertained* (1863), gained the attention and admiration of such prominent economists as Walter Bagehot and John Elliot Cairnes But his second work, *The Coal Question* (1865), brought Jevons more fame than he had ever dreamed of [13] Mill praised the book in a much-publicized parliamentary debate, and Gladstone purportedly revised his 1866 budget in response to Jevons's pessimistic findings (Jevons, *Papers*, III, 102-103; VII, 11-18) In the same year, Jevons was appointed Codben Professor of Political Economy and Professor of Logic, Mental and Moral Philosophy at Owens College, Manchester From that point on his career was set He served presidential terms with the British Association (Section F) and the Manchester Statistical Society, and in 1872, was appointed to the Royal Society [14] After ten years in Manchester, Jevons turned to London as Professor of Political Economy at University College, a position he held until his early retirement in 1880

When Jevons reissued his manifesto for mathematical economics in 1871, as the *Theory of Political Economy*, it received notices or reviews in virtually all of the prominent English periodicals [15] Although it was not always well received — Cairnes in particular challenged Jevons's new approach — by the mid-1870s Jevons had found a number of able supporters to assist him in his campaign One such follower was George Darwin, son of the famous naturalist and, perhaps even more important, a Second Wrangler His attack on Cairnes and defense of mathematical economics in an 1875 volume of the *Fortnightly Review* may have done much to advance Jevons's cause [16]

Reinforcements also came from abroad To one ally, Leon Walras, Jevons was quite forthright "I confess that I have always in my own mind attached much importance to this mathematical theory of economy, believing it to be the only basis upon which an ultimate reform of the science of political economy can be founded" (Jevons,

[13] To his sister, Jevons wrote in 1866, "excuse my being a little too full of myself at present It is hard even for me to feel the full meaning of such sudden and complete success If I had worked ten or twenty years longer, I might have been glad to have got the result I already have got' (Jevons, *Papers*, III, 97)

[14] Jevons was appointed primarily for his work in statistics and the natural sciences John Maynard Keynes, in his *Essays in Biography* (London Rupert Hart-Davis, 1951), made much of the fact that Jevons was the first economist to be appointed to the Royal Society since Sir William Petty (p 258) In fact, Thomas Malthus, if such a category is appropriate, would put Jevons in third place

[15] Brief notices were printed in the *Anthenaeum*, the *British Quarterly Review*, the *Westminster Review*, and the Manchester and London newspapers Full reviews appeared in the *Saturday Review* (anonymous), and *Academy* (Alfred Marshall), and the *Fortnightly Review* (J E Cairnes) These have been reprinted in Jevons, *Papers*, VII, 141-152 Apart from the popular magazines, only the *Contemporary Review* and *Quarterly Review* overlooked the *Theory*

[16] George Darwin, "The Theory of Exchange Value," *Fortnightly Review* 23 (February 1875), 244-253 Jevons received some letters, including one from Alfred Marshall, which endorsed Darwin's rebuttal of Cairnes (Jevons, *Papers*, IV, 100)

Papers, IV, 50) A year later, he wrote to Walras. "I have no doubt whatever about the ultimate success of our efforts, but it will take some fighting" (Jevons, *Papers*, IV, 104) Although the "fighting which transpired was relatively mild, it seems to have been effective By 1881, just one year before his life was cut short by a drowning accident, Jevons reported favorably to Walras· "I am glad to say I think the Math view of Economics is making much progress in England and is fully recognized by those competent to judge" (Jevons, *Papers*, V, 144) Subsequent economists have tended to agree with Jevons's observation William Ashley, for example, in a retrospective address of 1907, maintained that "among the diverse lines of thought which converged upon the old orthodoxy for its destruction in 1870-80, that represented by Jevons has for the time had the widest influence "[17]

Though Jevons wrote some nine books on economic topics, he regarded his *Principles of Science* as his most important publication (Jevons, *Papers*, III, 250) The work is commonly viewed as a response to the logical treatises of George Boole and J. S Mill but insofar as it uses numerous historical examples to illustrate its methodological claims, it is more akin to the work of John Herschel and William Whewell Jevons was clearly not a philosopher of the first rank Due in part to his preliminary training as a practical scientist, he had little patience for epistemological problems which might impede the task at hand, the defense of science as a legitimate means for the acquisition of knowledge John Maynard Keynes captured well the main thrust of Jevons's treatise on method when he remarked that "there are few books, so superficial in argument yet suggesting so much truth, as Jevons's *Principles of Science*."[18]

According to Jevons, all forms of reasoning originate in the recognition of identity or similarity. From this insight, that all inference consisted in the "substitution of similars," Jevons set out to reform Aristotelian logic. Propositions were formulated as algebraic equations, and deduction was nothing more than the mechanical substitution of

[17] William Ashley, "A Survey of the Past History and Present Position of Political Economy," in R L Smyth, ed , *Essays in Economic Method* (London Gerald Duckworth, 1962), p 232 Schumpeter has noted that the majority of major economists in the period 1870-1914 were acquainted with or actually practiced applied mathematics See Joseph A Schumpeter, *A History of Economic Analysis* (New York Oxford University Press, 1954), p 956

[18] John Maynard Keynes, *A Treatise on Probability* (London Macmillan, 1921), p 273 A contemporary critic made a similar judgment "[A]s a methodology he [Jevons] has fairly outstripped predecessors as great as Herschel, Whewell, and Mill [But] Jevons does not equal either Whewell or Mill in philosophical grasp He appears least at ease when he touches upon questions properly philosophical" (George Croom Robertson, "Mr Jevons's Formal Logic," *Mind*, 1 [1876], 207)

identical terms among the premises [19] In many respects, Jevons's system was little more than a simplified version of Boole's logic [20] But, taking issue with Boole, Jevons maintained that all of mathematics could be reduced, via the concept of number, to the more pervasive laws of logic In this way, Jevons stood Boole on his head; "Boole inverted the true order of proof when he proposed to infer logical truths by algebraic processes" (Jevons, *Principles*, p 113) Logic, not mathematics, was the most fundamental and hence the most certain branch of knowledge

Jevons maintained, more specifically, that his logic dealt exclusively with qualitative properties, with the intentionality of terms, and did not bear upon the quantitative properties or extensionality of objects [21] Quantity, then, was taken to be the criterion which demarcated mathematics from its logical foundations Although natural philosophers had often suggested that quantitative concepts were in some sense mathematical, Jevons made a concerted effort to ground this view in a system of formal logic Needless to say, his attempt to generate numbers from what he called "logical discrimination" did not win any converts But in his own mind he was quite confident that he had discovered the true relationship between mathematics and logic

Jevons's philosophical work belongs strictly to the tradition of British empiricism He accepted raw sense-data, in conjunction with a few immutable laws of logic, as the starting point of all knowledge. But in opposition to his immediate predecessors, Herschel, Whewell, and Mill, Jevons reverted back to David Hume's stand on induction. Scientists could never know for certain that the future would resemble the past, it was therefore impossible to identify true causal connections in nature, however much habit might lead us to believe otherwise Mill's celebrated rules of induction were thus untenable All scientific laws, Jevons argued, were probabilistic and subject to revision "Not one of the inductive truths which men have established, or think they have established, is really safe from exception or reversal" (Jevons, *Principles*, p 238)

Like the majority of his contemporaries, Jevons never seriously questioned the belief that scientific knowledge had progressed. But

[19] See Wolfe Mays and D P Henry, "Jevons and Logic," *Mind*, 62 (October 1953), 484-505

[20] See C I Lewis, *A Survey of Symbolic Logic* (1960, abridged ed , New York Dover, 1960), pp 37-78 and William Kneale and Martha Kneale, *The Development of Logic* (London Oxford University Press, 1962), pp 420-422

[21] For his explanation of this distinction, see Jevons, *Principles*, p 26 C I Lewis maintains that subsequent work has rendered the distinction superfluous, Jevons's system of logic would not be altered were extension to be incorporated See Lewis, p 73

throughout his writings, he emphasized the view that science had not made nearly as much progress as was commonly thought. No science, not even Newtonian physics, was perfect or complete The principle of inertia, the method for the composition of forces, even the very measurement of time and thus of motion, were subject to doubt "In truth men never can solve the problems fulfilling the complex circumstances of nature All laws and explanations are in a certain sense hypothetical, and apply exactly to nothing which we can know to exist. When we probe the matter to the bottom physical astronomy is as hypothetical as Euclid's elements "[22]

Jevons was one of the first to state succinctly what we now identify as the hypothetico-deductive method "In all cases of inductive inference," he maintained, "we must invent hypotheses, until we fall upon some hypothesis which yields deductive results in accordance with experience "[23] It was imperative that scientists continue to recognize that "before we attempt any investigation of facts, we must have correct theoretical notions" (Jevons, *Theory*, p. 22) Nature, nevertheless, could respond objectively to our attempts to fathom its ways Although the scientist must anticipate the study of nature with appropriate conceptual tools, the scientific method was still primarily an empirical enterprise:

> The investigator begins with facts and ends with them He uses facts to suggest probable hypotheses, deducing other facts which would happen if a particular hypothesis is true, he proceeds to test the truth of his notion by fresh observations If any result prove different from what he expects, it leads him to modify or to abandon his hypothesis, but every new fact may give some new suggestion as to the laws in action Even if the result in any case agrees with his anticipations, he does not regard it as finally confirmatory of his theory, but proceeds to test the truth of the theory by new deductions and new trials
>
> (Jevons, *Principles*, p 509)

Throughout the *Principles*, Jevons drew specific attention to the sheer diversity of our encounters with the external world: "Nature is a spectacle continually exhibited to our senses, in which phenomena are

[22] Jevons, *Principles*, p 458 Jevons identified several of the questionable or nontestable assumptions in Newtonian physics Even time, he noted, is measured purely according to convention [I]nasmuch as the measure of motion involves time, and the measure of time involves motion, there must be ultimately an assumption' (Jevons, *Principles*, p 309)

[23] Jevons, *Principles*, p 228 According to Peter Medawar, 'the account of scientific method which became recognized as the official alternative and rival to Mill's was not Whewell's but Stanley Jevons" (Peter B Medawar, *The Art of the Soluble* [London Methuen, 1967], p 149) For more detailed studies of Jevons s contributions to the philosophy of science, see John V Strong, "The Infinite Ballot Box of Nature De Morgan, Boole, and Jevons on Probability and the Logic of Induction," in *Proceedings of the Philosophy of Science Association* 1 (1976), 197-211, Larry Laudan, "A Note on Induction and Probability in the Nineteenth Century," in *Science and Hypothesis* (Dordrecht Reidel, 1981), and Edward H Madden, "W S Jevons on Induction and Probability," in *Theories of Scientific Method* (Seattle University of Washington Press, 1966), pp 233-247

mingled in combinations of endless variety and novelty" (Jevons, *Principles*, p 1) It was therefore necessary that scientists recognize "how hopeless it would be to attempt to treat nature in detail" (Jevons, *Principles*, p 190) Science must restrict itself to the study of only a fraction of the possible combinations to be found in nature Furthermore, from any given set of observations, one could formulate an almost endless number of hypotheses It was quite remarkable that science had managed to emerge in the first place, or to continue to grow This strongly suggested that "the Universe in which we dwell is not the result of chance" (Jevons, *Principles*, p 2) Although the first step towards a sound theory was a matter of hit or miss, once a breakthrough had been made, nature undoubtedly guided the way "Chance then must give us the starting point; but one accidental observation well used may lead us to make thousands of observations in an intentional and organised manner, and thus a science may be gradually worked out from the smallest opening" (Jevons, *Principles*, p 400)

One of the most important heuristic devices in this random search for the laws of nature was the discernment of analogies, either within one branch of science or between different branches Although the use of analogies was commonplace among nineteenth-century scientists, Jevons went to great lengths to demonstrate the validity of such a practice Reasoning by analogy was, quite simply, another version of his all-pervading principle of the substitution of similars "All science, arises from the discovery of identity, and analogy is but one name by which we denote the deeper-lying cases of resemblance" (Jevons, *Principles*, p 629). The legitimacy of this practice was definitely reinforced by Jevons's conviction that "all the sciences meet somewhere." But he found empirical support as well Numerous cases in the history of science, for example the researches of René Descartes and Michael Faraday, suggested that "the discovery of an unsuspected analogy between two branches of knowledge has been the starting-point for a rapid course of discovery" (Jevons, *Principles*, p 631) Clearly the most expedient means by which to improve economic theory, for Jevons at least, was to seek analogies between it and the more advanced sciences

II

Jevons maintained that "every science as it progresses will become gradually more and more quantitative (Jevons, *Principles*, p

273) And, given his system of logic, as soon as "quantitative notions enter, the science must be mathematical in nature" (Jevons, *Theory*, p 7) Classical physics exemplified the fact that the use of a "clear, brief, and appropriate system of symbols . . is almost essential to the expression of those general truths which are the very soul of science" (Jevons, *Principles*, p. 13) Eventually, Jevons claimed, scientific theories would reach such a degree of sophistication that the scientist and mathematician would be indistinguishable from one another "As a science progresses, its powers of foresight rapidly increases, until the mathematician in his library acquires the power of anticipating nature, and predicting what will happen in circumstances which the eye of man has never examined" (Jevons, *Principles*, p 526)

By analogy, economics must follow suit Jevons did not have to establish the view that economics was already a deductive science. On the contrary, the popular press had continually attacked the "dismal science" for being too logical, too prone to lengthy syllogizing His case was therefore not a difficult one to make. Since economics also already had a quantitative complexion, it was simply a matter of urging economists to take advantage of mathematical methods, to render explicit the true character of their discipline: "Economists have long been mathematicians without being aware of the fact. The unfortunate result is that they have generally been bad mathematicians, and their works must fall. Hence the explicit recognition of the mathematical character of the science was an almost necessary condition of any real improvement of the theory" (Jevons, *Theory*, p xxiii) Since the proper domain of logic was restricted to "pure quality, as apart from quantity," a nonmathematical approach to economics could not adequately treat the quantitative relationships of the market The assistance of mathematics must be sought. "All economic writers must be mathematical so far as they are scientific at all, because they treat of economic quantities, and all quantities and relations of quantities come within the scope of mathematics" (Jevons, *Theory*, p. xxi) However self-evident or simplistic this might sound to us, it must be remembered that Jevons was one of the first to ascribe logical foundations to mathematics, and to attempt to arrive at criteria which nonetheless distinguished the one branch of knowledge from the other

Contrary to what one might suppose, Jevons believed that the degree of certainty of a given theory would never be increased through the application of mathematics Although mathematics might clarify or add rigor to rudimentary scientific ideas, it could never add to the initial truth of the theoretical claims. Indeed, for Jevons, mathematics

itself, as it strayed further from strictly logical considerations, became increasingly more dubious. If there was any certainty to be found in mathematics, it was derived from its roots in logic· "The mathematician is only strong and true as long as he is logical, and if number rules the world, it is logic which rules number" (Jevons, *Principles*, p. 154). Thus, primarily as a result of his study and revision of the logic of Boole and of Mill, Jevons did not adopt a commonly revered attribute of mathematics

Jevons also drew a careful distinction between an exact and a mathematical science It so happened that as the physical sciences had increased their mathematical profile, they had also tended to become more exact, but this did not imply that a mathematical science need be exact Not only did the history of science suggest that "physicists are, of all men, most bold in developing their mathematical theories in advance of their data," but this incautious approach was possibly the only way in which to further scientific knowledge; "had physicists waited until their data were perfectly precise before they brought in the aid of mathematics we would have still been in the age of science which terminated at the time of Galileo" (Jevons, *Theory*, p 6).

Jevons attempted, consequently, to undermine the belief that mathematics, if introduced to a scientific theory, would imply greater exactitude than was warranted: "Many persons entertain a prejudice against mathematical language, arising out of a confusion between the ideas of a mathematical science and an exact science. They think that we must not pretend to calculate unless we have the precise data which will enable us to obtain a precise answer to our calculations; but, in reality, there is no such thing as an exact science, except in a comparative sense" (Jevons, *Theory*, p. 5) Both certainty and exactitude were viewed as functions of the degree of accordance between fact and theory and were thus assessed after the pure ratiocinative process to which mathematics was applied

Although mathematics did not have the virtue of making a science more certain or more exact, it could assist in the discernment of the degree of exactitude, "the approximate character of physical science will be rendered more plain if we consider it from a mathematical point of view" (Jevons, *Principles*, p 471). This was most evident during the procedure of "quantitative induction," which for Jevons characterized an important part of the scientific method. Insofar as scientists attempt to join together various observations into mathematical functions, all scientific laws, Jevons maintained, were basically of the form. $y = A + Bx + Cx^2 + Dx^3 + Ex^4 +$

(Jevons, *Principles*, pp 471-503). The degree of approximation was measured, quite simply, by the number of terms) In principle, every function ought to have an infinite number of terms but, in practice, Jevons acknowledged that scientists had seldom found more than one or two terms Mathematical functions, accordingly, were viewed as the end product of scientific inquiry Not only did they reveal the approximate nature of all scientific laws but, by simply connecting phenomena without reference to the operation of causes, they helped to reinforce the view that all scientific knowledge must necessarily fall short of identifying the *vera causa* of nature

It followed from all of this that economics, in emulating the physical sciences, did not have as far to go as might have been supposed Jevons emphasized the fact that the natural sciences were not so successful at predicting and explaining the world And, since mathematics was no longer upheld as the absolute source of certainty, its application to the deductive science of economics would commit no injustice Nor need the use of mathematics, as Mill had suggested, imply that greater precision or exactitude had thereby been achieved [24] On the contrary, it was not only possible to devise a mathematical theory prior to any extensive accumualtion of data but, Jevons argued, this had been the very path commonly taken by the leading physical scientists

III

In his specific treatment of economic theory, Jevons attempted to establish, wherever possible, algebraic functions between the relevant quantities. His most famous insight was the principle commonly known today as diminishing marginal utility Assuming that the mind can recognize varying degrees of pleasure and pain, and assuming that net pleasure or utility is generated by the acquisition or consumption of commodities, then there comes a point such that, as the units of a particular commodity are increased, the additional

[24] Mill s objections are spelled out in a section of his *Logic* entitled "Function of mathematical truths in the other sciences ' John Stuart Mill, *Collected Works of John Stuart Mill*, John M Robson, ed (Toronto University of Toronto Press, 1962-), vol VII, *A System of Logic* (1973), 620-621 One commentator has suggested that Mill also believed that the use of algebra in economics would suggest that precise and universal laws had thereby been achieved (N B de Marchi, "Mill and Cairnes and the Emergence of Marginalism in England, ' *History of Political Economy*, 4 [Fall 1972], 344-363)

increments or degrees of utility yielded decrease in magnitude In Jevons's words, "*the degree of utility varies with the quantity of commodity, and ultimately decreases as that quantity increases* "[25] He next assumed that the units could be treated as infinitesimals which, by rendering the utility function continuous, opened the way for the calculus "Believing that the quantities with which we deal must be subject to continuous variation, I do not hesitate to use the appropriate branch of mathematical science The theory consists in applying the differential calculus to the familiar notions of wealth, utility, value, [etc.] As the complete theory of almost every other science involves the use of that calculus, so we cannot have a true theory of Economics without its aid" (Jevons, *Theory*, p 3)

From his study of physics, Jevons fully appreciated the role the calculus had played in the development of mechanics He proposed that an analogous system of mechanics be devised for economics which could then serve as the point of departure for all future research· "As all the physical sciences have their basis more or less obviously in the general principles of mechanics, so all branches and divisions of economic science must be pervaded by certain general principles It is to the investigation of such principles — to the tracing out of the mechanics of self-interest and utility, that this essay has been devoted The establishment of such a theory is a necessary preliminary to any drafting of the superstructure of the aggregate science" (Jevons, *Theory*, pp. xvii-xviii) The first step towards the formulation of an economic mechanics had already been taken by the classical economists, namely the treatment of economics as a purely deductive science In this respect Jevons believed that the methods of economics are "as sure and demonstrative as that of kinematics or statics" (Jevons, *Theory*, p 21) Economists, moreover, had already identified some of the basic postulates of their science which, like mechanics, were few and simple There were, however, many additional parallels to be drawn

Jevons took the phenomena of exchange, the prices and quantities in the marketplace, as the starting point of all economic inquiry For centuries, moral philosophers had grappled with the problem of exchange-value and had attempted to explain, either directly or indirectly, the system of relative prices in terms of some

[25] Jevons, *Theory*, p 53 Jevons set out in algebraic form that both u and du/dx are functions of the commodity x, where u stands for utility But he chose to present the more fundamental relationship of the eventual decrease of the degree of utility in the form of a graph rather than with the simple inequality $d^2u/dx^2 < 0$

more fundamental or intrinsic form of value. Jevons's new approach consisted in taking the prices as phenomena, pure and simple, as the only positive form of value This was in direct accordance with one of the principle canons of science: "Among the most unquestionable rules of scientific method is that first law that *whatever phenomenon is, is* We must ignore no existence whatever, . if a phenomenon does exist, it demands some kind of explanation" (Jevons, *Principles*, p 769). It was not the case, then, that prices, due to market disturbances, fluctuate about some natural or absolute value. Rather, every price which appears in the market, no matter how short-lived, "demands some kind of explanation "

According to Jevons, all economic actions stemmed from an imbalance, within any particular mind, of pleasure and pain Feelings were thus the underlying forces of his economic mechanics But it was not necessary, as many of his critics believed, that the feelings be measured directly. All that Jevons need assume was that the mind had the capacity to distinguish between two feelings of similar magnitude "The theory turns upon those critical points where pleasures are nearly, if not quite, equal, . that when a man has purchased enough, he would derive equal pleasure from the possession of a small quantity more as he would from the money price of it" (Jevons, *Theory*, p 13) In the act of exchange, prices were taken to be the manifestation of this mental balancing act. Economic phenomena were thus reducible to mental states and ultimately to the laws of psychology For Jevons, his "theory presumes to investigate the condition of a mind, and bases upon this investigation the whole of Economics" (Jevons, *Theory*, pp 14-15)

To justify this explanation of prices by something as subjective and inscrutable as the human mind, Jevons turned to mechanical analogies:

> A unit of pleasure or of pain is difficult even to conceive, but it is the amount of these feelings which is continually prompting us to buying and selling, borrowing and lending, producing and consuming, and *it is from the quantitative effects of the feelings that we must estimate their comparative amounts* We can no more know nor measure gravity in its own nature than we can measure a feeling, but, just as we measure gravity by its effects in the motion of a pendulum, so we may estimate the equality or inequality of feelings by the decisions of the human mind The will is our pendulum, and its oscillations are minutely registered in the price lists of the markets
>
> (Jevons, *Theory*, pp 11-12)

In an 1872 letter to Cairnes, Jevons extended the various parallels to the physical sciences

> The method seems to me exactly analogous to that employed in other theoretical subjects such as that of light, heat, electricity, &c Scientific men assume those properties as they like, calculate what would happen on such conditions and then by comparison with facts ascertain whether they are correct They have no means of measuring the properties of the ether except by arguing back from observation So there is no means of measuring pleasure & pain directly, but as those feelings govern sales and purchases, the prices of the market are those facts from which one may argue back to the intensity of the pleasures concerned
>
> (Jevons, *Papers*, III, 246-247)

In Jevons's depiction of exchange, two persons barter their respective goods in continuous increments until they reach the point where they are indifferent to obtaining an additional infinitesimal amount of the commodity at the rate of exchange just reached In this approach, the very act of exchange alters the price continuously To simplify the analysis, for a complete account would have to explain how a single observed and stable price could emerge from numerous pairs of ongoing exchange, Jevons proposed that the market be analyzed in a state of static equilibrium, in effect, at the point at which all exchange had just ceased: "The real condition of industry is one of perpetual motion and change Commodities are being continually manufactured and exchanged and consumed If we wished to have a complete solution of the problem in all its natural complexity, we should have to treat it as a problem of motion — a problem of dynamics. But it would surely be absurd to attempt the more difficult question when the more easy one is yet so imperfectly within our power It is only as a purely statical problem that I can venture to treat the action of exchange" (Jevons, *Theory*, p 93) Jevons was fully aware that "in practice, no market ever long fulfils the theoretical conditions of equilibrium" (Jevons, *Theory*, p 111) But, as he had argued at length with respect to the physical sciences, even the most established of them was to a certain extent hypothetical Economists, accordingly, were entitled to make some simplifying assumptions [26]

In order to justify his retreat from confronting the difficult problem of market dynamics, Jevons once again invoked an analogy to mechanics His exchange equation, he argued, took precisely the same form as the equation for the law of the lever when analyzed with the aid of the theory of virtual velocities So remarkable were the formal parallels that Jevons believed that he had demonstrated "the

[26] Again, he drew a specific analogy to mechanics "It is much more easy to determine the point at which a pendulum will come to rest than to calculate the velocity at which it will move when displaced from that point of rest Just so, it is a far more easy task to lay down the conditions under which trade is completed and interchange ceases, than to attempt to ascertain at what rate trade will go on when equilibrium is not attained" (Jevons, *Theory*, p 94)

mathematical character of the equations of exchange by drawing an exact analogy between them and the equations applying to the equilibrium of the lever" (Jevons, *Theory*, p. xiii, see also pp. 102-106 for this "demonstration"). Both the law of exchange and the law of the lever used the concept of an infinitesimal displacement from a position of static equilibrium and thus called for a limited use of the calculus

Indeed, Jevons was so enthralled by this analogy that he suggested the time had come to restore the principle of virtual velocities to its fundamental place in mechanics, a view once held by Joseph Louis Lagrange [27] According to Jevons, "the mode in which mechanics is usually treated in elementary work tends to disguise the real foundation of the science which is to be found in the so-called *theory of virtual velocities*" (Jevons, *Theory*, p. 102) Jevons adopted this outmoded stand in order to justify his relatively meager use of the calculus in his analysis of exchange Although he was adamant that the "true" theory of economics necessarily required the calculus, he admitted on occasion that he was not "capable of presenting the subject in the concise symbolic style satisfactory to the taste of a practiced mathematician "[28] Subsequent commentators have borne out the view that Jevons had cause to defend his less-than-rigorous mathematics. According to A. A. Young, Jevons simply gave a "mathematical garb to results reached by nonmathematical reasoning "[29]

The Jevonian theory also assumed that the fundamental postulates, for example that "human wants are more or less quickly satiated," were universally applicable. This was a major departure from the classical theorists, who had maintained that the initial axioms of political economy pertained only to the advanced industrial nations. Jevons, on the other hand, went to the other extreme. Not only could economists observe the postulates in the economic behavior of the Eskimos, but they might also one day trace their action "among some of the more intelligent classes of animals "[30] Jevons's transformation of

[27] Lagrange, in his Mèchanique Analytique (1788), did pay tribute to this principle, now known as the principle of virtual work $\Sigma m_i \vec{v}_i d\vec{v}_i = 0$

[28] Jevons, *Theory*, p xiii Jevons excused his limited facility with mathematics with the remark that he was writing, not for mathematicians, "but as an economist wishing to convince other economists that their science can only be satisfactorily treated on an explicitly mathematical basis (Jevons, *Theory*, pp xiii-xiv)

[29] Allyn A Young, "Jevons's Theory of Political Economy," in *Economic Problems New and Old* (Boston Houghton Mifflin, 1927), p 230

[30] William Stanley Jevons, ' The Future of Political Economy," in *The Principles of Economics and Other Papers*, Henry Higgs, ed , (1905, rpt ed , New York Augustus M Kelly, 1965), p 197 We know from a letter to his wife that Jevons partly intended the claim about animals as a joke See Jevons, *Papers*, IV, 182

economics into a universal science was made in direct imitation of mechanics "The theory of the science [of economics] consists of those general laws which are so simple in nature, and so deeply grounded in the constitution of man and the outer world, that they remain the same throughout all those ages . Just as there is a general science of mechanics, so we must have a general science or theory of economy" (Jevons, "Future of Political Economy," p 198)

In keeping with this new view of economics as a science of universal scope, Jevons treated certain factors in the classical theory, particularly those with historical dimensions, as exogenous to his model Thus, a population, a system of technology, a medium of exchange, and an institutional process for the distribution of income were all assumed to be given at the outset The central problem of economics became, in Jevons's hands, a problem of maximizing utility under certain constraints "*Given, a certain population, with various needs and powers of production, in possession of certain lands and other sources of material required, the mode of employing their labour which will maximise the utility of the produce*" (Jevons, *Theory*, p. 267)

Although Jevons has here formulated economics as a problem of optimization, as a problem which cried out for a solution using the differential calculus, he was unable to solve it mathematically To his credit, Jevons acknowledged his limitations "Two or three correspondents have pointed out that a little manipulation of the symbols, in accordance with the simple rules of the differential calculus, would often give results which I have labouriously argued out. The whole question is one of maxima and minima, the mathematical conditions of which are familiar to mathematicians" (Jevons, *Theory*, p xiii)

Jevons had to be content to justify the overriding need for the calculus in part by his assumption that the relevant quantities could be treated in continuous terms and in part by his relatively ad hoc analogy to the law of the lever

Although Jevons's actual performance in mathematical economics fell short of his prescriptions, his overall approach to economics was nonetheless markedly different from the one taken by his predecessors. Whereas the classical economists had concentrated on long-term growth, on the ways and means to increase the wealth of nations in conjunction with specific institutional traditions and technological innovations, Jevons viewed the economy as a mechanism for the atemporal allocation of scarce resources in accordance with

simultaneously reckoned, individual desires Apart from considerations for the validity of his psychological assumptions, the primary focus of pure economic theory became little more than a matter of applied mathematics The mere presence of algebraic formulae, moreover, conveyed the impression that economics had been transformed into a global science It was not simply by chance that Jevons urged his readers to follow him by renaming the discipline economics rather than political economy [31] And, once the system of economic mechanics was laid out, it would be possible to construct an "aggregate science" to handle the more peripheral topics of banking, tariffs, and taxation Jevons had thereby initiated fundamental changes, not only in the methods of economics, but also in its very scope

In conclusion, Jevons's "worldly philosophy" was derived from a curious mixture of a Victorian faith in the unity of knowledge and a relatively impressive understanding of the limitations of science As one of the first commentators on the logics of Boole and Mill, Jevons had hit upon a novel approach to the status of mathematical knowledge More specifically, by establishing a criterion which demarcated mathematics from its roots in logic, and by recognizing, in opposition to Mill, that a mathematical treatment of scientific theories did not entail greater exactitude or certainty, Jevons had discovered the path by which mathematics could secure its rightful place in the "dismal science " Indeed, an algebraic analysis of the quantitative relationships of the economy would actually serve to clarify the approximate nature of such knowledge

Jevons's system of logic also gave him an open license to develop historical and formal analogies between economics and the more advanced sciences Just as physics had become increasingly more quantitative and thus mathematical, so, Jevons contended, must economics First, however, it was necessary to construct a general system of mechanics which, like its counterpart in physics, would be mathematical, reductionist, and universally applicable Simply put, the prices and quantities of the market place were to be reduced to a "calculus of pleasure and pain " Although a complete analysis of the market called for a system of dynamics, Jevons attempted to vindicate his more restricted "solution" of exchange in static equilibrium by various analogies to the science of mechanics, more specifically, to the

[31] In the second edition of the *Theory*, Jevons consistently replaced every occurrence of "political economy with "economics," with the sole exception of the title itself See *Theory*, pp xiv-xv Alfred Marshall s *Principles of Economics* (1890) established the modern appellation

principle of virtual velocities as applied to the law of the lever In fact, it was this analogy which provided Jevons with the means to defend his specific, albeit limited, use of the differential calculus

Jevons's attempts to found economics on a "mechanics of utility and self-interest" did not have a permanent impact According to Lionel Robbins, economists have since retreated to the less contentious realm of "revealed preferences" and a "logic of choice "[32] But they have continued to utilize mathematical techniques Indeed, judging from the list of Nobel Laureates in economics, it appears that many of the recent prominent economists could almost be identified as applied mathematicians [33] Jevons's image of the scientist as "mathematician in his library" may, in the case of economics, already be partially realized Although his overall role in this transformation may not have been as significant as others, our findings here indicate that, at least in his case, the study of the historical and philosophical dimensions of the physical sciences was undoubtedly of fundamental importance

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[32] See Lionel Robbins, 'The Place of Jevons in the History of Economic Thought, *Manchester School*, 7 (1936), 6-7

[33] See Joel Franklin, Mathematical Methods in Economics, *American Mathematical Monthly*, 90 (April 1983), 229-244 Of the twelve prizes given in the years 1969-1981, seven were for work which Franklin deems primarily mathematical The two most recent awards, to George Stigler and Gerard Debreu, fall under the same category

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AT THE INTERSECTION OF MATHEMATICS AND HUMOR: LEWIS CARROLL'S *ALICES* AND SYMBOLICAL ALGEBRA

AUGUSTUS DE MORGAN INTRODUCED CHAPTER II OF HIS *Trigonometry and Double Algebra* of 1849 with a précis of symbolical algebra· "*With one exception*, no word nor sign of arithmetic or algebra has one atom of meaning throughout this chapter, the object of which is *symbols, and their laws of combination*, giving a *symbolic algebra* "[1] Slightly over fifteen years later, Lewis Carroll's Alice interrupted the trial of the Knave to state her opinion of the nonsense verse read by the White Rabbit "*I* don't believe," Alice declared, "there's an atom of meaning in it "[2]

The coincidence of language in De Morgan's algebraic textbook and Carroll's *Alice's Adventures in Wonderland* is not accidental Charles Lutwidge Dodgson's mathematical training and interests influenced the literary works he published under the pseudonym of Lewis Carroll The *Alices* embodied the mathematician Dodgson's misgivings about symbolical algebra, the major British contribution to mathematics of the first half of the nineteenth century The theme of meaninglessness, emphasized in earlier interpretations of the *Alices*,[3] can be traced back to Dodgson's encounter with the symbolical approach, the roots of his nonsense verse may also be in symbolical algebra, which stressed in mathematics structure over meaning.

Evidence of Dodgson's familiarity with symbolical algebra should help to correct the popular misconception that the author of the

[1] Augustus De Morgan, *Trigonometry and Double Algebra* (London Taylor, Walton, and Maberly, 1849), p 101 I wish to thank Roland Stromberg, who encouraged me to write a paper on humor and Victorian mathematics

[2] Lewis Carroll, *Alice's Adventures in Wonderland*, in *The Annotated Alice*, ed Martin Gardner (New York Clarkson Potter, 1960), p 159 All citations in my text of *Alice's Adventures in Wonderland* and *Through the Looking-Glass* refer to *The Annotated Alice*

[3] See, for example, Donald Rackin, "Alice's Journey to the End of Night, ' *PMLA*, 81 (October 1966), 313-326, and "Blessed Rage Lewis Carroll and the Modern Quest for Order," in *Lewis Carroll A Celebration*, ed Edward Guiliano (New York Clarkson Potter, 1982), pp 15-25

Alices knew nothing of the advanced mathematics of his period [4] In fact, where earlier scholars have seen only ignorance of symbolical algebra, I will argue that Dodgson's rejection and ridicule of symbolical algebra was well informed, but based on a conservative view of mathematics Furthermore, I will demonstrate that there was before the *Alices* at least limited precedent for combining humor and mathematics. Specifically, William Frend and Augustus De Morgan, nineteenth-century mathematicians of some note, shared Dodgson's humorous bent and anticipated his exploitation of algebraic themes for humorous effect

I

In the early nineteenth century, mathematics occupied a preeminent position in English thought and education It was revered as a paradigm of knowledge and an exceptional instrument for mental training In theory, according to some of its defenders, mathematics taught sound reasoning better than any other subject, in practice, it was the core of studies at Cambridge University. Through almost midcentury, in fact, no Cambridge undergraduate could achieve honors in any subject without first demonstrating proficiency in mathematics [5]

Mathematics owed its privileged position to the period's acceptance of the traditional view of it as a science of absolute truths which flowed deductively from self-evident first principles about clear and

[4] Offering this standard interpretation of Dodgson's mathematics, Tony Beale, for instance, writes "The giants of the English mathematical world were to be found at Cambridge, and there is no evidence to suggest that Dodgson read or had any interest in their work" (Tony Beale, "C L Dodgson Mathematician," in *Mr Dodgson Nine Lewis Carroll Studies* [London The Lewis Carroll Society, 1973], p 26) Similarly, Norman T Gridgeman declares Dodgson "out of touch with the mathematical research of his day," citing specifically his ignorance of non-Euclidian geometry (*Dictionary of Scientific Biography*, 16 vols [New York Charles Scribner's Sons, 1970-1980] under "Dodgson, Charles Lutwidge") More cautiously, Florence Becker Lennon, relying on Eric T Bell's analysis of Dodgson's mathematical library, assures readers that Dodgson's possession of algebra textbooks by Bland and Wood "in preference to the available Peacock, is indicative of C L D 's low mathematical taste and poor aptitude for mathematics" (Florence Becker Lennon, *Victoria through the Looking-Glass The Life of Lewis Carroll* [New York Simon and Schuster, 1945], p 346)

On the other hand, modern scholars give Dodgson credit for rather advanced work in symbolic logic But the present paper concerns symbolical algebra rather than symbolic logic The two were, even in Dodgson's lifetime, distinct Symbolic logic developed after and to a certain extent out of symbolical algebra, symbolical algebra was mathematics, while symbolic logic was a partly mathematical and partly philosophical study of the reasoning process Thus in 1865 De Morgan distinguished logic from mathematics "The necessary matter of thought, that without which we cannot think, consists of Space and Time These form the subject matter of the Mathematics The consideration of the necessary *Laws* of thought, on the other hand, constitutes Logic" ("Speech of Professor De Morgan," *Proceedings of the London Mathematical Society*, 1 [1865], 4)

[5] For general remarks on the role of mathematics in the pre-Darwinian Cambridge curriculum, see Martha McMackin Garland, *Cambridge before Darwin The Ideal of a Liberal Education, 1800-1860* (Cambridge Cambridge University Press, 1980), pp 28-51

distinct ideas Thus, in 1831, touting mathematics as the best instrument for mental training, Augustus De Morgan declared·

It is necessary to *learn to reason* before we can expect to be able to reason Now the mathematics are peculiarly well adapted for this purpose, on the following grounds

1 Every term is distinctly explained, and has but one meaning, and it is rarely that two words are employed to mean the same thing
2 The first principles are self-evident, and, though derived from observation, do not require more of it than has been made by children in general
3 The demonstration is strictly logical, taking nothing for granted except the self-evident first principles, resting nothing upon probability, and entirely independent of authority and opinion
4 When the conclusion is attained by reasoning, its truth or falsehood can be ascertained, in geometry by actual measurement, in algebra by common arithmetical calculation
5 There are no words whose meanings are so much alike that the ideas which they stand for may be confounded [6]

In short, distinctness and meaningfulness of terms, self-evidence of first principles, deductive development, and availability of "experimental" tests of its conclusions — all combined to guarantee the certainty of mathematics and thereby to justify its preeminence as a body of knowledge and a tool of education

At the very time when mathematics was so central to English intellectualism, however, a small group of Cambridge mathematicians was undermining its claim as an absolute science These mathematicians invented a new approach to algebra in response to the problem of the negative and imaginary numbers, one which stressed structure and logical certainty rather than meaning and physical applicability. Although regarded as somewhat questionable when introduced into European mathematics during the Renaissance, the negative and imaginary numbers emerged as a clearly defined problem only in the late eighteenth century, when critics declared that they could form no clear concept of either kind of number, and that the standard definitions of both were nonsensical Textbooks of the period defined a negative number as a "quantity less than nothing" or a "quantity obtained by the subtraction of a greater from a lesser quantity." Who, the critics challenged, could conceive of a "quantity less than nothing"? The concepts "less than nothing" and "quantity," they argued, were inconsistent Furthermore, the definition of an imaginary number led to a contradiction. Imaginaries were (and are) numbers which, when squared, produced negative numbers Critics supposed there was a number b such that b^2 equalled -1. Then, they

[6] Augustus De Morgan, *On the Study and Difficulties of Mathematics* (1831, 2d rpt ed , Chicago Open Court, 1902), pp 7-9 (This edition is drawn from the original, with corrections of "numerous errata and typographical solecisms," by Thomas J McCormack)

pointed out, b was either positive or negative But this conclusion was impossible, since, when squared, both positive and negative numbers give positive results In short, opponents of the negatives and imaginaries claimed that these numbers introduced absurdity into the paradigm of clear concepts and absolute truths They therefore called for total rejection of these numbers and reduction of algebra to the study of non-negative whole numbers and fractions [7]

While many mathematicians recognized the problem of the negative and imaginary numbers, most refused to abandon these particularly fertile mathematical concepts Instead of rejecting negatives and imaginaries, a few British mathematicians redefined algebra Thus in the early 1830s George Peacock responded to the problem of the negatives with formulation of the symbolical approach to algebra In addition to arithmetic, there was, Peacock argued, symbolical algebra — "the science which treats of the combinations of arbitrary signs and symbols by means of defined though arbitrary laws " Rather than define the negatives and imaginaries in a traditional fashion, Peacock chose to redefine algebra as a science dealing with undefined signs and symbols, governed by laws of the mathematician's making According to this approach, algebraists were free to manipulate undefined or meaningless symbols; only after the manipulations were they to concern themselves with meaning Peacock's motto was "Interpretation will *follow*, and not *precede* " Because the meaning of algebraic signs and symbols was not stressed, emphasis was put on the rules or forms of algebra As the symbolical approach altered mathematicians' views concerning the concepts of mathematics (such as the negative number), so it forced a rethinking of the source and standing of mathematical rules or first principles. Peacock tentatively and others more explicitly recognized that mathematicians determined the rules of algebra [8]

In illustration of this new approach, Peacock introduced the sign "x" as a meaningless symbol. Then, asserting his freedom as a mathematician to determine the rules governing the sign, he declared that "x" was the inverse of " − " and followed the form $a \times b = b \times a$ What was important about "x" was the collection of forms or rules

[7] A good discussion of the British problem of the negative and imaginary numbers is Ernest Nagel, " 'Impossible Numbers' A Chapter in the History of Modern Logic,' *Studies in the History of Ideas*, 3 (1935), 429-474

[8] George Peacock, *A Treatise on Algebra* (Cambridge J and J J Deighton, 1830), p 71, George Peacock, "Report on the Recent Progress and Present State of Certain Branches of Analysis, *Report of the Third Meeting of the British Association for the Advancement of Science*, 3 (1833), 195 See Helena Pycior, "George Peacock and the British Origins of Symbolical Algebra," *Historia Mathematica*, 8 (1981), 23-45, especially pp 32-40

which it followed, not its meaning Initially meaningless, "x" eventually took on different interpretations: it stood for arithmetical multiplication, for example; also, for the multiplication of line segments (Peacock, *Treatise on Algebra*, pp. 72-73, 84-87). In short, with the symbolical approach, the traditional image of mathematics as a science of meaningful terms, self-evident principles and absolute truths began to crumble Coming into vogue was a view of algebra as a study of meaningless signs and symbols, governed by somewhat arbitrary rules and subject to many different interpretations The traditional goal of mathematics, absolute truth, was giving way to a goal of useful and logically certain conclusions. Symbolical algebraists admitted that they could guarantee only that algebraic conclusions were the result of good deductive reasoning applied to assumed first principles — not that these conclusions were necessarily true in any absolute or empirical sense

Responses to symbolical algebra were mixed There were its proponents, led for awhile by Peacock and Duncan F Gregory There were also opponents: a young Cambridge graduate, Osborne Reynolds, for example, who published a stinging critique of the new approach to algebra In another category were those who helped to develop symbolical algebra but whose reactions to it were ambivalent It is clear, for example, that although De Morgan for a time was strongly attracted to the new algebra and even embraced it, he later assigned it a secondary place behind meaningful algebra [9]

Responses to negative numbers and to symbolical algebra occasionally took the form of humor Themes such as the apparent paradox of the negatives — "quantities less than nothing" — and the meaninglessness and arbitrariness of symbolical algebra lent themselves to humorous exploitation One of the three major Victorians who combined humor and algebraic themes, William Frend, for example, wrote an unpublished play in which he humorously and assertively attacked both the negatives and symbolical algebra De Morgan, a more established mathematician, did not go as far as Frend in the application of humor to mathematics, yet published a review of one of his own mathematics books which spoofed double algebra (his meaningful algebra which developed after and, to a certain extent, out of symbolical algebra) Later, Dodgson, a mathematician by vocation

and a fantasy writer by avocation, incorporated algebraic themes into his *Alices*

The earliest representative of this Victorian intersection of mathematics and humor, Frend was one of the most influential opponents of the negative and imaginary numbers [10] As such, his writings against the negatives were usually scientific rather than humorous. Clarity and independence of thought led him to recognize the paradoxical in the standard definition of negatives as quantities less than nothing As a mathematician, he tried first to resolve the paradox His answer involved nothing less than total rejection of the negative and imaginary numbers and all algebraic results depending on them Occasionally, however, as in a public letter to the Vice-Chancellor of Cambridge, Frend assumed a more assertive tone in dealing with the negatives and their defenders The intent of the letter to the Vice-Chancellor was incongruous with Frend's position in regard to Cambridge. Frend wrote to apply for the Lucasian professorship, even though five years earlier (in 1793) he had been banished from the University In the letter, Frend objected to the fundamental theorem of algebra, which states that an equation of the nth degree has n roots (The theorem is based on acceptance of negative and imaginary roots) He then challenged other applicants for the position to calculate all the roots of a given equation of the 99th degree If he obtained the professorship, Frend promised, he would share his salary with anyone producing the required 99 roots and demonstrating certain relationships among them [11] Frend's dare was hardly side-splitting humor Yet it was less neutral and more aggressive than his usual response to the negatives In the letter, temporarily exercising his humorous bent, Frend was clearly exploiting rather than resolving the paradox of the negatives

Frend also turned humorist in an essay satirizing the mathematical concept of nothing, which he published in 1803, and in a spoof-play which he (and possibly his daughter, Sophia Elizabeth)[12] composed in response to De Morgan's *Elements of Algebra* of 1835 The essay was not as effective as the play Unlike the play, the essay was

[10] Frend's opposition to the negative numbers is discussed in Augustus De Morgan, "William Frend,' *Memoirs of the Royal Astronomical Society*, 12 (1842), 460-463, and Nagel, "Impossible Numbers," pp 435-437 See also Frida Knight, *University Rebel The Life of William Frend (1757-1841)* (London Victor Gollancz, 1971)

[11] William Frend, *A Letter to the Vice-Chancellor of the University of Cambridge* (Cambridge n p , 1798)

[12] The complete play, along with a discussion of its authorship, appears in Helena Pycior, "Historical Roots of Confusion among Beginning Algebra Students A Newly Discovered Manuscript,' *Mathematics Magazine*, 55 (1982), 150-156 (The play survives as an anonymous manuscript)

imitative and did not sufficiently exploit the mathematically ridiculous It was an imitation of Rabelais, centered on a request for Pantagruel to decide the fate of the concept of nothing in the universities Frend clearly had in mind popular objections to mathematicians' liberal use of zero in algebraic operations, including division What, the essay implicitly asked, does it mean to divide by zero? How many times does nothing go into something? The essay's theme as well as the flatness of its humor were captured at its very end in Pantagruel's response to the assigned question "They who can make something out of nothing shall have nothing to eat at the court of — PANTAGRUEL "[13]

Frend's play, written in the late 1830s, succeeded where the earlier essay failed, largely because its subject matter, symbolical algebra, provided a larger target for Frend's humor In the play, Frend attacked the newly developed algebra partly by exploiting its acceptance of the negatives and its arbitrariness In particular, he exaggerated the mathematician's freedom to determine the rules of algebra In scene two, for example, Professor De Morgan (the play's protagonist whom Frend borrowed from real life) is hired to teach mathematics to a group of Cambridge undergraduates. The ensuing negotiations concerning De Morgan's salary provide an opportunity for ridiculing the arbitrariness of symbolical algebra Initially, the students set De Morgan's fee at £ 7/1000 or "one thousandth part of what any other professor ever had," based on their assumption that he can teach a thousand times as fast as the others But De Morgan disagrees with both their conclusion and the methods by which they arrived at it Parodying rather closely a section on the negative numbers from the real De Morgan's *Elements of Algebra*, the protagonist De Morgan states.

Stay A little too fast We will turn to my book on Algebra, where you will find the anomaly you speak of, explained (*P[rofessor De Morgan], takes up a book & after reading a great many p s and q's goes on*) It is evident that we have made this equation wrong All that we have to do, is, to suppose the case the direct reverse of what we have stated it

Suppose that instead of receiving 1/1000th part of what other Professors have I were to receive 1000 times as much The equation then becomes Fee for one course = £ 7 x 1000 This renders the problem rational for it is evident that a man who has the power of 1000 men must receive as much as 1000 others *Vide* page 34 of my Elements of Algebra wherein I explain the meaning of half a horse, two men & three quarters &c

[13] William Frend, Pantagruel's Decision of the Question about Nothing," in Augustus De Morgan, *A Budget of Paradoxes*, ed David Eugene Smith, 2d ed , 2 vols (Chicago Open Court, 1915), I, 214 De Morgan reports that Frend s essay was originally published in 1803 in *The Gentlemen's Monthly Miscellany*, a periodical with a life of less than a year (*Budget of Paradoxes*, I, 208)

The very end of the play humorously attacks both the arbitrariness of symbolical algebra and the negative numbers. The students decide to return to Cambridge and, addressing De Morgan, one declares "As terms are entirely arbitrary, we think it very arbitrary in you to name such high terms for your course of lectures, and as the greater number may always be taken from the lesser I vote that we all take ourselves away to Cambridge" (Pycior, "Historical Roots," pp. 154-156)

In real life De Morgan was a creator and sometimes proponent of symbolical algebra He was also Frend's son-in-law and his mathematical heir-apparent, who shared his distaste for the traditional definitions of negative and imaginary numbers and his multiple creative talents for mathematics and humor. Unlike Frend, he was an established mathematician and assumed a humorous approach to algebra only infrequently Yet wit marked De Morgan's public and private responses to mathematical quackery (circle-squaring and the like), his regular columns for the *Athenaeum*, and his notebooks which he sprinkled with cartoons

De Morgan believed that it was difficult for a mathematician to direct stinging wit at sound mathematics The understanding of mathematics, he suggested, incapacitated the mathematician for ridiculing it Thus, De Morgan noted, his humor was usually employed against mathematical quackery and "in favor of [the mathematical] establishment" (*Budget of Paradoxes*, I, 319). In the *Athenaeum* and in the *Budget of Paradoxes* (which drew heavily on his contributions to the *Athenaeum*), De Morgan ridiculed cyclometry, or the attempt to square the circle despite a mathematical proof of the impossibility of the task. He made sport of the cyclometers as a group, attacked some personally, and even wrote a parody of the cyclometers' essays. He dismissed the cyclometer as a "pseudomath [or] a person who handles mathematics as the monkey handled the razor The creature tried to shave himself as he had seen his master do; but, not having any notion of the angle at which the razor was to be held, he cut his own throat He never tried a second time, poor animal! but the pseudomath keeps on at his work, proclaims himself clean-shaved, and all the rest of the world hairy" (*Budget of Paradoxes*, II, 338)

De Morgan reserved his special humorous invective for James Smith, whom he dubbed "the great pseudomath of our time" He estimated that Smith had sent him "six pounds avoirdupois of pamphlets and letters" on circle-squaring and that Smith's books would "one day reach from Simpkin & Marshall's to Kew, placed upright, or to Windsor laid lengthways" When Smith's supporters criticized his

handling of the cyclometer, De Morgan replied "His friends complain that I do nothing but *chaff* him. Absurd! I winnow him; and if nothing but chaff results, whose fault is that?" De Morgan's parody of circle-squaring singled Smith out for special ridicule Following the cyclometers, De Morgan announced that he had solved the problem of squaring the circle by finding the value of π or the ratio of the circumference of a circle to its diameter The key to the problem's solution, he claimed in jest, was recognition of the fact that the ratio varied "with the time, in a maner [*sic*] depending upon the difference of the true longitudes of the Sun and Moon " Smith's value of π, he added, was the correct one for the varying ratio at the time of the full moon (*Budget of Paradoxes*, II, 338, 342, 338, 343, 316)

In one instance, De Morgan's humor ran riot on the topic of algebra In an anonymous review of his own *Trigonometry and Double Algebra* of 1849, he described the book as an attempt to "set algebra on two legs, which had hitherto hopped on one "[14] Appealing to biped animals, "analytic beer," and the like — that is, to various bisociations of double algebra and objects from everyday life — he managed to explain his rather technical book in clear terms The review was, in short, an effective use of humor in the popularization of mathematics

By the mid-nineteenth century, there was thus a small but significant tradition of combining humor and mathematics Frend's writings showed that an opponent of the negatives and of symbolical algebra could use humor to air and exaggerate the seeming paradox of the former and the mathematical novelties of the latter De Morgan proved that humor could be turned against mathematical quackery and also employed by a (sometimes lukewarm) symbolical algebraist to promote understanding of the new algebra and related developments

II

The tradition of mathematical humor and its inclusion in nontechnical magazines such as the *Athenaeum* can be at least partially attributed to widespread popular interest in mathematics among the English of the eighteenth and nineteenth centuries England's numerous amateur mathematicians guaranteed a receptive audience for such humor and themselves generated some of it. Possibly attracted

[14] [Augustus De Morgan], review of "Trigonometry and Double Algebra," by Augustus De Morgan, *Athenaeum* (1849), p 277 De Morgan acknowledged authorship of this review by initialing it in his copy of the journal, now found in the University of London Library

to mathematics as the best instrument for training the human mind and as one requiring no expensive equipment, the amateurs contributed to periodicals featuring mathematical materials, formed their own mathematical societies, and apparently purchased the many popular textbooks on mathematics which appeared throughout the first half of the nineteenth century. *The Lady's Diary· or the Woman's Almanac* (1704-1840) and Thomas Leybourn's *Mathematical Repository* (1795-1835) were leaders among popular magazines with significant mathematical content In general, these magazines — whose contributors included university mathematicians as well as rank amateurs — catered to sound mathematics rather than quackery, but in a setting less formal than that of the scientific journals of the period Thus *The Lady's Diary* (also known as *The Ladies' Diary*) regularly carried mathematical problems and solutions, but, at least initially, contributors were supposed to frame the problems and their solutions in verse [15]

In addition to corresponding with one another privately and publicly in journals, some of England's eighteenth and nineteenth-century mathematical enthusiasts formed societies devoted to the pursuit of science in general or mathematics in particular. The most famous popular mathematical society, the Old Mathematical Society of Spitalfields (1717-1845), was originally an organization of artisans. Each member brought "his pipe, his pot, and his problem" to weekly meetings at which he was free to pose any mathematical question to any other member who, in turn, was under a formal obligation to answer it "in the plainest and easiest manner he [was] able" (*Budget of Paradoxes*, I, 376). The Old Society dabbled in humor and verse in addition to mathematics, as witnessed by its "Drinking Song" reproduced in De Morgan's *Budget of Paradoxes*. The song began·

> Whoe'er would search the starry sky
> Its secrets to divine, sir,
> Should take his glass — I mean, should try
> A glass or two of wine, sir!
> True virtue lies in golden mean,
> And man must wet his clay, sir,
> Join these two maxims, and 'tis seen
> He should drink his bottle a day, sir!
> (I, 380)

The eighteenth and nineteenth-century tradition of popular mathematics and mathematical humor formed the background to the

[15] For analysis of this popular English mathematical literature, see Geoffrey Howson, *A History of Mathematics Education in England* (Cambridge Cambridge University Press, 1982), pp 69-71

work of not only Frend and De Morgan but Charles Dodgson as well Dodgson shared this common setting with Frend and De Morgan, and also their multiple creative talents, mental habits, and, to a certain degree, concern for algebraic foundations The three men were all exceptionally clear thinkers Neither Dodgson nor Frend, for example, would read a page of a mathematics textbook beyond what he understood As Dodgson once explained "I would sometimes, after working a week or two at some new book get into a hopeless muddle My rule was *to begin the book again* I have several books that I have begun over and over again "[16] Both Dodgson and De Morgan "liked to exercise ingenuity in riddles, numerical puzzles, plays on words and puns "[17] Both also seemed to delight in trying to refute the fallacious claims of angle-trisectors, circle-squarers, and other mathematical quacks Florence Lennon has noted that, "without believing that the circle could be squared, at the death of De Morgan [Dodgson] inherited an immense correspondence with those who did" (Lennon, *Victoria through the Looking-Glass*, p 5) In the introduction to his *Curiosa Mathematica*, Dodgson himself attacked circle-squaring as a "delusive phantom" and reviewed the futile correspondence in which he had tried to convince two would-be circle-squarers of their errors [18]

The intellectual relationship between Dodgson and De Morgan went deeper than mutual distaste for cyclometry. The mathematical (and logical) interests, work, and styles of the two men overlapped, with De Morgan clearly inspiring the younger mathematical don For example, both published works on the fifth book of Euclid's *Elements*: De Morgan, the greater mathematician, covered incommensurables as well as commensurables, Dodgson confined his attention to the latter [19] Both defended Euclid's *Elements* against newer textbooks on geometry. Thus, in 1868, De Morgan wrote an unfavorable review of J M Wilson's *Elementary Geometry* About a decade later, writing under the pseudonym of Lewis Carroll, Dodgson followed suit with *Euclid and His Modern Rivals*, which attacked the newer basic geometries of

[16] Lewis Carroll to Edith Rix, 13 February 1885, in *The Letters of Lewis Carroll*, 2 vols , ed Morton N Cohen, with the assistance of Roger Lancelyn Green (New York Oxford University Press, 1979), I, 559 Hereafter cited as *Letters* This and other extracts from the *Letters* are reprinted with permission of the publisher

[17] William Gaunt and M D E Clayton-Stamm, *William De Morgan* (London Studio Vista, 1971), p 11 This is a description of Augustus De Morgan, but fits Dodgson as well

[18] Charles L Dodgson, *Curiosa Mathematica, Part I A New Theory of Parallels*, 4th ed (London Macmillan, 1895), pp xvi-xviii

the period Attesting to De Morgan's influence, Dodgson reproduced in an appendix extensive selections from De Morgan's review of Wilson's book [20] Furthermore, Dodgson's major work on symbolic logic fit into the new school of logic created by De Morgan and George Boole around the mid-nineteenth century In his *Symbolic Logic*, Dodgson referred to De Morgan and adapted one of the latter's logical problems for his own use.[21] In addition to sharing some mathematical and logical interests, Dodgson and De Morgan both aimed at popularizing sound mathematics, sometimes through books written in nontechnical styles De Morgan's *Connexion of Number and Magnitude*, which employed the form of a dialogue, found a stylistic counterpart in Dodgson's *Euclid and His Modern Rivals*, composed as a play [22]

In spite of these strong similarities, Dodgson and De Morgan seem to have split on the issue of symbolical algebra Contrary to accepted scholarship, Dodgson knew something of the symbolical algebra for which Frend indirectly and De Morgan directly had been responsible, but Dodgson seems never to have accepted the new algebra He probably became acquainted with the problem of the negative and imaginary numbers very early in life and read at least sections of George Peacock's *Treatise on Algebra* by the year of the publication of *Alice in Wonderland* [23] Dodgson's knowledge of Peacock's *Treatise* by 1865 is indisputable In "The New Method of Evaluation as Applied to π" of that year, Dodgson alluded to the fundamental principle of Peacock's symbolical approach The "New Method" was a satirical pamphlet on the controversy surrounding the proposal to raise the salary of the Regius Professor of Greek. In the pamphlet Dodgson offered various pseudo-mathematical resolutions of the debate, including

[20] Lewis Carroll, *Euclid and His Modern Rivals*, 2d ed (1885, rpt ed , New York Dover, 1973), pp 246-251

[21] Lewis Carroll, *Lewis Carroll's Symbolic Logic*, ed William Warren Bartley, III (New York Clarkson Potter, 1977), pp 30, 362, 439-440

[22] The production of elementary textbooks on mathematics was a natural response of established mathematicians to the widespread interest in their subject characteristic of the eighteenth and nineteenth centuries De Morgan, for instance, wrote a number of popular textbooks for the Society for the Diffusion of Useful Knowledge

[23] It is possible that Dodgson came away from Richmond School, which he attended in the 1840s, with a rudimentary interest in the conceptual gaps in traditional algebra In 1830, dedicating his *Treatise on Algebra* to James Tate, his headmaster at Richmond School, Peacock wrote that the book would "recall the subject of many interesting conversations with you [Tate]" (Peacock, *Treatise on Algebra*, p iii) While Tate's son assumed control of Richmond in 1833, it is probable that a critical perspective on traditional algebra still prevailed at the school during Dodgson's school years Furthermore, if poorly defined algebraic concepts were criticized by any Richmond students, Dodgson would surely have been among the critics Of him, the younger Tate wrote, 'he is capable of acquirements and knowledge far beyond his years, while his reason is so clear and so jealous of error, that he will not rest satisfied without a most exact solution of whatever appears to him obscure" (quoted in Stuart Dodgson Collingwood, *The Life and Letters of Lewis Carroll* [1899, rpt ed , Detroit Gale, 1967], p 25)

one based on "the principle known as 'the permanence of equivalent formularies' "[24] This was an obvious adaptation of the "principle of the permanence of equivalent forms," crucial to Peacock's development of symbolical algebra (*Treatise on Algebra*, especially pp. xvii-xviii and 103-105) Furthermore, evidencing more than a cursory acquaintance with Peacock's work, Dodgson referred to a section of the *Treatise on Algebra* in his book on determinants, which he published just two years after the "New Method "[25]

Dodgson's mature introduction to advanced mathematics, including symbolical algebra, seems to have taken place a decade before publication of *Alice in Wonderland* — during the summer of 1854 when, nearing completion of his undergraduate program at Christ's Church, Oxford (which was sorely deficient in mathematics and science), he studied mathematics under Bartholomew Price, then a fellow and tutor of Pembroke College From Price, Dodgson learned calculus "swimmingly "[26] In addition, he discussed algebra with Price, whose publications of the 1840s attest to a knowledge of Peacock's *Treatise*, despite a strong predilection for meaningful mathematics.[27] Thus, also from Price, Dodgson probably acquired a familiarity with and ambivalence towards symbolical algebra. As indicated by one of Dodgson's letters written during this summer to Mary Dodgson, Price encouraged him to question the legitimacy of extending algebraic terms to cover situations beyond their original definitions. Dodgson now asked what multiplication of lines could mean Multiplication of a real number by a counting number is easy to conceptualize and define Thus, four times five involves taking five four times, or adding five to five to five to five But as evidenced by Peacock's *Treatise*, nineteenth-century mathematics had moved far beyond multiplication by counting numbers Negatives were routinely multiplied by negatives, imaginaries by imaginaries, and even lines by lines (see pp. 72-73, 84-87) Taking his characteristically literal approach, Dodgson questioned the appropriateness of using a single term "multiplication" to cover operations on such different objects as numbers and lines. As he

[24] Charles Dodgson, "The New Method of Evaluation as Applied to π," in *The Complete Works of Lewis Carroll* (1936, rpt ed , New York Random House, Vintage, 1976), p 1127

[25] Charles Dodgson, *An Elementary Treatise on Determinants with Their Application to Simultaneous Linear Equations and Algebraical Geometry* (London Macmillan, 1867), p v The reference is to a point of traditional, rather than symbolical, algebra

[26] Charles Dodgson to Mary Dodgson, 23 August [1854], in *Letters*, I, 29

[27] Bartholomew Price, *A Treatise on the Differential Calculus, and Its Application to Geometry Founded Chiefly on the Method of Infinitesimals* (London, n p , 1848), p 138, Bartholomew Price, *An Essay on the Relation of the Several Parts of a Mathematical Science to the Fundamental Idea Therein Contained* (Oxford The Ashmolean Society, 1849), especially pp 5-7

explained, "my question was solely one of *words*. 'What likeness is there in the two *operations* to justify our calling them by the same *name*?' I am not nearly satisfied yet on the subject "[28] Dodgson was clearly not satisfied with Peacock's resolution of the general question of the extension of algebraic terms, whereby an algebraic operation (such as multiplication) was defined through the rules governing it and without any concern for the meaning of the operation or the symbols operated on

This letter and Dodgson's published mathematical works imply that he never became a convert to symbolical algebra In his mathematical publications and teaching, he seems to have shied away from algebraic questions, concentrating rather on geometry and logic. When his publications referred to algebra, it was to traditional, meaningful algebra Thus his *Guide to the Mathematical Student*, intended "to exhibit, in a compendious form, the whole subject-matter of Pure Mathematics, arranged in the order in which it would usually be advisable that the student should go through it," listed "higher algebra" as the twenty-third of twenty-six subjects to be studied, but gave no indication that such algebra was to include anything beyond the standard theory of equations of the period The list made no mention of symbolical algebra.[29]

Dodgson ignored symbolical algebra because it was inimical to the traditional view of mathematics which he held to the end of his life: algebraic meaninglessness and arbitrariness went directly counter to his deep-seated belief in the absolute certainty or truth of mathematics. It was, indeed, according to Dodgson, its certainty which made mathematics superior to other sciences and therefore attractive to the human mind Thus in *Curiosa Mathematica*, Dodgson explained that other sciences led to provisional knowledge, but·

> The charm [of mathematics] lies chiefly, I think, in the absolute *certainty* of its results for that is what, beyond almost all mental treasures, the human intellect craves for Let us only be sure of *something*! More light, more light! "And, if our fate be death, give light and let us die!" This is the cry that, through all the ages, is going up from perplexed Humanity, and Science has little else to offer, that will really meet the demands of its votaries, than the conclusions of Pure Mathematics
>
> (p xv)

Dodgson's reference to "absolute *certainty*" made it clear that, for him, mathematics guaranteed more than logical certainty (or assurance of

[28] Charles Dodgson to Mary Dodgson, 23 August [1854] in *Letters*, I, 28

[29] Charles Lutwidge Dodgson, *A Guide to the Mathematical Student in Reading, Reviewing, and Working Examples, Part I Pure Mathematics* (Oxford J H and J Parker, 1864), preface A second part never appeared

the logical affiliation of certain ideas) It guaranteed truth — in Dodgson's words, "certain universally-true Theorems," some of which were "provable from genuine Axioms (i e from Axioms whose self-evident character is indisputable) " Attending Dodgson's belief in self-evident axioms leading to true theorems was, of course, commitment to the meaningfulness of mathematics. According to him, mathematics began first of all with human penetration of the meaning of the axioms, and then assent to them. "Now," he wrote, "there is one preliminary step, that is absolutely indispensable before the human intellect can accept any Axiom whatever and that is, it must attach some *meaning* to it We cannot, rationally, either assent to, or deny, any Proposition the words of which convey to us no idea" (*Curiosa Mathematica*, pp. xv, 62, 67-68) Thus the certainty — and hence the beauty and intellectual significance — of mathematics depended ultimately on meaningful, self-evident axioms, the opposite of the meaningless, arbitrary signs, symbols, and rules of symbolical algebra It is, then, no wonder that Dodgson, mathematical teacher and author, steered clear of the new algebra

III

While symbolical algebra found no place in Dodgson's mathematics and teaching, there is evidence to suggest that it worried him and played upon his imagination in such a way that he was led to express his concern in the *Alices* Dodgson's struggle with the question of algebraic meaning, hinted at in his letter to Mary Dodgson in the summer of 1854, and his composition of the germs of *Alice in Wonderland* coincided in time As a fellow student in Price's reading party of the summer of 1854 later recounted:

> Dodgson and I were both pupils of Professor Bartholomew Price in a mathematical Reading Party at Whitby in the summer of 1854 It was there that *Alice* was incubated Dodgson used to sit on a rock on the beach, telling stories to a circle of eager young listeners of both sexes These stories were afterwards developed and consolidated into their present form
>
> (Quoted in *Letters*, I, 26)

Thus, it was with visions of lines multiplied by lines, quantities less than nothing, and symbolical algebra dancing in his head that Dodgson first set about constructing an other-world (the underground) in which meaninglessness and arbitrariness prevailed

Writing under his pseudonym, Dodgson touched on the problem of the negative numbers at least three times in the *Alices* While he never used the term "negative," he approached the problem through the definitions of the negatives as "quantities less than nothing" and "quantities obtained by taking a greater from a lesser " In two of the instances, the dialogue between characters indicated that such subtraction — something from nothing or a greater from a lesser — was impossible, in the third, the subject was abruptly changed, apparently to avoid an explicit response to the problem In *Alice in Wonderland*, the Mad Hatter proclaims the impossibility of subtracting something from nothing In the tea party scene, the March Hare offers Alice "more tea " Alice replies that she has "had nothing yet [and] so can't take more " This provides the opportunity for the Hatter's comment. "You mean you can't take *less* it's very easy to take *more* than nothing" (p 101) Later in the same work, the Mock Turtle refuses to deal with the problem, when it is raised in a practical context by Alice Describing his early schooling, the Mock Turtle relates that his lessons lessened (or decreased) day by day On the first day of his studies, he worked for ten hours, on the second, nine hours; and so on Ever inquisitive, Alice first asks whether he rested on the eleventh day, to which he replies affirmatively (Ten hours minus ten hours, of course, equals zero hours) Pushing beyond the zero point, Alice next inquires "And how did you manage on the twelfth?" (p 130), thereby bringing the discussion around to the problem of the negatives. Neither Turtle nor Gryphon responds to Alice's last question; the latter abruptly changes the topic of conversation from lessons to games. In *Through the Looking-Glass*, the problem of the negative numbers reappears as the Red Queen asks Alice to subtract nine from eight This time, apparently having acquired some mathematical subtlety between the first and second *Alices*, Alice objects to what she now sees as impossible subtraction [30]

In the first two instances, Carroll exploited the paradox of a quantity less than nothing He took the concept literally, and forced his readers to consider less tea than that contained in an empty cup and fewer hours of study than none. In contrast to such mathematicians as De Morgan, who sought viable analogues of the negative numbers in such concrete objects as financial debts and lines drawn backwards from a zero point, Carroll presented physical situations in which "quantity less than nothing" was nonsensical In the third case, from

[30] Alice's response to the Red Queen's request is "Nine from eight I can't, you know" (p 320)

Through the Looking-Glass, he reinforced the absurdity of subtracting a greater from a lesser number by having the request for such impossible subtraction come from the quite arbitrary Red Queen and presenting it as one of a series of preposterous pseudo-mathematical problems, such as dividing a loaf by a knife and subtracting a bone from a dog In short, Carroll borrowed from mathematics the theme of the negative numbers and, writing as a humorist rather than a mathematician in the *Alices*, aggressively highlighted its nonsensical implications

The *Alices* refer not only to the problem of the negatives but also, directly and indirectly, to the breakdown of mathematics as a science of absolute truths following development of the symbolical approach to algebra Alice's recognition of the potential meaninglessness and arbitrariness of mathematics, in fact, comes early in *Alice in Wonderland* Subjected to the vagaries of her underground experience, such as changes in her size, Alice comes to question even her identity. She wonders if she is Ada or Mabel, two of her above-ground friends. In this epistemological crisis, reminiscent of Descartes' in the *Discourse on Method*, Alice imitates the French philosopher by trying to establish what she knows with certainty It is not surprising that Alice turns first to mathematics, given its privileged position in Victorian culture If there is any truth or certainty in the natural world, her Victorian contemporaries would have agreed, it is evidenced by mathematics But at this point mathematics fails to prove a bedrock of knowledge Alice multiplies in a nondecimal base and finds that the multiplication leads nowhere in particular For review, Alice says

> "I'll try if I know all the things I used to know Let me see four times five is twelve, and four times six is thirteen, and four times seven is — oh dear! I shall never get to twenty at that rate! However, the Multiplication Table doesn't signify let's try Geography "
>
> (p 38)

Carroll's choice of a varying nondecimal base is designed, I believe, to indicate the arbitrariness of mathematics [31] Mathematicians are free to calculate in any base they choose, there is nothing sacred about the base ten But in addition to the arbitrariness of mathematics, the passage alludes to its meaninglessness Alice clearly states that "the Multiplication Table doesn't signify " Besides punning on the meaninglessness of mathematics, the verb "signify" for Carroll may also have

[31] For a brief discussion of different interpretations of Alice's calculations, see Gardner, *The Annotated Alice*, p 38

been associated with mathematical writings of the symbolical algebraists, where it was frequently used.[32] Their main point — and Alice's as expressed here — was that algebra (in Alice's case, arithmetic) is basically meaningless, that its symbols (here, numbers) stand for nothing in particular Alice finds that mathematics is no mainstay of truth and certainty, and cannot save her from the madness of the underground world. Viewed from this perspective, the meaninglessness and arbitrariness of symbolical algebra provide a key to the meaninglessness and arbitrariness of Carroll's underground world.

Beyond inspiring particular examples of nonsense, it is possible that symbolical algebra inspired, or at least fostered, Carroll's nonsense style The parallels between Carroll's nonsense writings and symbolical algebra are striking· both stressed form or structure over meaning, using words (or other symbols) with multiple possible interpretations Put succinctly, the symbolical algebraists sought formulas relating symbols which, although originally meaningless, could eventually be interpreted as representatives of many different mathematical phenomena. As De Morgan explained in a review of Peacock's *Treatise on Algebra*:

> We ask, whether it might not be possible so to vary the meaning of the signs, as to make an entirely different algebra, which should nevertheless present exactly the same theorems in form as the old one, the forms having different meanings This may seem something like asking, whether two different languages might have all their words in common, but with different meanings, in such manner that by writing a treatise on astronomy in the first language, we write, *totidem verbis*, a treatise on music in the second [33]

As is well known, in the *Alices* Carroll experimented with nonsense prose and verse — with meaningless sentences, or words with structure but no specific meaning. Alice repeatedly remarks on the phenomenon. Thus in the mad tea-party episode, Alice is described as "dreadfully puzzled The Hatter's remark seemed to have no sort of meaning in it, and yet it was certainly English 'I don't quite understand you,' she said, as politely as she could" (p 97). Towards the end of *Alice in Wonderland*, the phenomenon of complete sentences without apparent meaning resurfaces, in the episode of the White Rabbit's nonsense verse, evidence mentioned at the start of this essay. Echoing

[32] In *Trigonometry and Double Algebra*, De Morgan used the term "significant algebras" for those in which all symbols and combinations of symbols were meaningful (p 101)

[33] [Augustus De Morgan], review of "A Treatise on Algebra," by George Peacock, *Quarterly Journal of Education*, 9 (1835), 104-105

De Morgan's description of symbolical algebra, Alice declares. "*I* don't believe there's an atom of meaning in it" (p. 159) [34]

Remarks made by the Hatter towards the end of the tea party raise a question of fundamental interest to the early symbolical algebraists: how universal are algebraic symbols? Peacock and the period's other algebraists characterized symbols as simultaneously "arbitrary" (standing for nothing in particular) and "universal" (standing for many different things). Critics sometimes ridiculed the symbolical approach by exploring the consequences of interpreting algebraic symbols as absolutely universal (standing for all possible mathematical entities).[35] The Hatter applies the latter interpretation to words (rather than algebraic symbols) in sentences (rather than mathematical formulas) "You can draw water out of a water-well," the Hatter says, "so I should think you could draw treacle out of a treacle-well — eh, stupid?" (p 102) The structure of the two sentences is the same (you can draw *b* out of a *b*-well), but the content is different In the language of symbolical algebra, the symbol *b* is universal, or subject to multiple meanings such as water and ink But *b* is not absolutely universal; there are some nouns, such as treacle, which, when substituted for *b*, leave the sentence with no empirical signification. The point of Carroll's humor now seems clear: structure does not guarantee meaning, emphasis on structure over meaning, so basic to the symbolical approach, can lead to nonsense.

But, the period's symbolical algebraists might very well have replied, nonsense results only when symbols are accepted as absolutely universal in interpretation. This retort, however, raises another problem, also alluded to in the *Alices*· who determines appropriate interpretations of symbols (be they algebraic or ordinary language symbols)? Asked this question by Alice, Humpty Dumpty makes two points: words (like algebraic symbols) can have multiple meanings and he (like the symbolical algebraist) gets to determine those meanings (pp 269-270) [36] The Humpty Dumpty episode thereby exploits both

[34] The case for symbolical algebra as an inspiration and model for Dodgson's nonsense is strengthened by the observation that his early nonsense verse, "She's All My Fancy Painted Him" and "Stanza of Anglo-Saxon Poetry" (the first four lines of the later "Jabberwocky"), appeared in 1855, or just after Dodgson's reading party with Price The former poem was published in *The Comic Times* of London (Gardner, *The Annotated Alice*, p 158), the latter, included in Dodgson's 'Mischmasch" (*The Rectory Umbrella and Mischmasch by Lewis Carroll* [New York Dover, 1971], p 139)

[35] For a discussion of early nineteenth-century confusion on this point, including an analysis of Peacock's failure to distinguish explicitly between universal and absolutely universal symbols, see Pycior, "Early Criticism of the Symbolical Approach," pp 403-404

[36] Viewed from the perspective of algebra, Alice's "puzzled" reaction to Humpty Dumpty s dictum that "a word means just what I choose it to mean — neither more nor less' (p 269) is an autobiographical reference to Dodgson's initial response to the algebraist's use of the term "multiplication" to cover the cases of whole numbers and lines

the emphasis on structure over meaning and the related arbitrariness of symbolical algebra

The argument that Lewis Carroll had symbolical algebra in mind fits well with the meaninglessness which Donald Rackin finds in the *Alices* Lacking knowledge of the history of English algebra (readily available only in the last decade), Rackin nevertheless appealed to concepts which, when viewed from this new perspective, suggest a connection between the *Alices* and symbolical algebra According to Rackin, Alice's "quest serves, vicariously, as the reader's metaphorical search for meaning in the lawless, haphazard universe of his deepest consciousness".

> Merely to list the reverses Alice encounters in Wonderland is to survey at a glance an almost total destruction of the fabric of our so-called logical, orderly, and coherent approach to the world Practically all pattern, save the consistency of chaos, is annihilated First, there are the usual modes of thought — ordinary mathematics and logic in Wonderland they possess absolutely no meaning Next are the even more basic social and linguistic conventions these too lose all validity the essence of Alice's adventures beneath commonly accepted ground is the grimmest comedy conceivable, the comedy of man's absurd condition in an apparently meaningless world
>
> (Rackin, "Alice's Journey," pp 313-314)

Alice, of course, finally rebels against the meaninglessness of Wonderland According to Rackin, the rebellion sets in when she meets the King and Queen of Hearts. As the rulers of Wonderland, they "should hold the secret of their realm's meaning and be the ultimate source of its order." But the King, Queen, and their attendants are, as Rackin says, "mere abstract, manufactured, and arbitrary symbols — just a pack of cards, pictures of kings and queens, men and women" (Rackin, "Alice's Journey," p 322)

Here Dodgson's acquaintance with symbolical algebra can illuminate Rackin's analysis The *Alices* deal with the search for meaning in a meaningless world — a world in which even mathematics no longer signifies. The loss of meaningful mathematics is tantamount to the loss of human certainty, since as Dodgson indicated in his mathematical works, mathematics alone guaranteed absolute truth Thus, the breakdown of mathematics signals "an almost total destruction of our coherent approach to the world." Graphic evidence of this destruction is the card people, who are realizations of the worst fears of the opponents of the symbolical approach They are mere symbols (like a, b, and c) — "abstract, manufactured, and arbitrary," as

Rackin puts it [37] This response of Carroll to symbolical algebra in the *Alices*, then, suggests that the crises of faith which the Victorians experienced were not always the result of the breakdown of religion under the impact of science Carroll was concerned instead, albeit humorously, with the breakdown of older mathematical certainty under the impact of the new algebra

Elizabeth Sewell's view of nonsense as a game similarly accords well with the claim for symbolical algebra as an antecedent of Carroll's literary works "If neither prose nor poetry," she asks, "can provide the necessary structure for Nonsense, is there some other system by which language could be organized into an independent and consistent, if nonsensical, structure?" She finds such structure in game rules, or "an enclosed whole, with its own rigid laws which cannot be questioned within the game itself "[38] This description fits symbolical algebra, or any other modern mathematical system But more importantly from an historical perspective, in appealing to the analogy of the game, Sewell hit on the exact analogy used by De Morgan when trying to explain symbolical algebra to his contemporaries As early as 1835, for example, De Morgan compared mathematics to dominoes; later, he compared symbolical algebra to putting together a dissected map whose pieces had been turned upside down [39]

In short, the theses of the tradition of combining mathematics and humor as a background to Dodgson's stories and of an integral relationship between his algebraic views and the *Alices* are well supported [40] The latter thesis also fits well with earlier interpretations of the *Alices* The facts that the *Alices* deal with a search for meaning in a meaningless world, that Dodgson's nonsense emphasizes structure over meaning, that the analogy of a game is appropriate to his

[37] Alice s disdain for the card people ("You re nothing but a pack of cards!" [p 161]) matches that of Osborne Reynolds — a leading opponent of the symbolical approach — for the symbols of the early symbolical algebraists their symbols "are intended to represent nothing but themselves, and are in meaning, as in appearance, symbols only", and "a *symbol*, or anything *merely symbolical*, is *nothing*, until some representation is given to it" ([Osborne Reynolds], *Structures on Certain Parts of Peacock s Algebra" by a Graduate* [Cambridge, 1837], p 7)

[38] Elizabeth Sewell, *The Field of Nonsense* (London Chatto and Windus, 1952), pp 24-25 Sewell unwittingly also sets up a striking parallel between Carroll's nonsense and symbolical algebra She notes "What is to be conveyed [in Carroll's nonsense] will have to be gathered not from *what* is said so much as *how* it is said, as if the content lay hidden in the structure of the work The 'meaning', if such it may be called, will be difficult of access, since it will reside in the structure, and that has first to be apprehended, as in a mathematical or logical problem" (Sewell, p 22) On a similar note, Peacock explained that "in symbolical algebra, the rules determine the meaning of the operations, or more properly speaking, they furnish the means of interpreting them" (Peacock, "Report, p 200)

[39] De Morgan, review of "A Treatise on Algebra," p 95, De Morgan, "On the Foundation of Algebra, No II," *Transactions of the Cambridge Philosophical Society*, 7 (1842), 289-290

[40] As Dodgson was not the first Victorian to combine mathematics and humor, so he was not the last See William Kingdon Clifford, Thomas Penyngton Kirkman, Edwin A Abbott, and Charles Hinton

literature, and that Dodgson was acquainted with and yet uneasy about the symbolical approach all point to symbolical algebra as a major influence on the *Alices*. The *Alices* were, at least partly, expressions of Dodgson's anxiety over the loss of certainty implicit in mathematicians' acceptance of the symbolical approach Alice's bewilderment in Wonderland paralleled Dodgson's bewilderment in the mathematical world of the symbolical algebraists Alice's response to the chaos of the underground — retreat — paralleled Dodgson's response to symbolical algebra — the ignoring of it in his serious mathematical writings and teachings. But while Alice could flee Wonderland and leave the chaos behind, Dodgson could never completely escape the symbolical approach. Denied a place in his mathematics, the themes and techniques of symbolical algebra found an outlet in his fantasy writings

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MUSEUMS AND IDEOLOGY: AUGUSTUS PITT-RIVERS, ANTHROPOLOGICAL MUSEUMS, AND SOCIAL CHANGE IN LATER VICTORIAN BRITAIN

BY THE CLOSE OF THE VICTORIAN ERA, THE GREAT NATIONAL DEPOSITORIES of culture and natural knowledge which had marked London's preeminence in letters and learning had been imitated throughout the industrial centers and county towns of Britain. The British and South Kensington Museums could be observed on a lesser scale in Liverpool and Glasgow, Salisbury and Cardiff, Leicester and Belfast Just as the waves of educational reform had reshaped and invigorated institutions of primary, secondary, and university education, so had they helped inspire the establishment of supplemental museum foundations which catered to the desire for self-improvement on the part of the artisan and middle classes.[1] The new museums in large part were the successors and spiritual legatees of the early nineteenth-century literary and philosophical societies. But they were also, on the whole, public foundations which served the needs of entire urban or county constituencies

I

The Museum Movement in nineteenth-century Britain had its origin in the early decades of the century, experienced steady growth

[1] There are many sources which deal with the topic of self-education as an accepted means of status building and upward mobility among the middle and upper-working classes in Victorian Britain The role of museums in feeding and deriving from this movement is understudied R O Gray, *The Labour Aristocracy in Victorian Edinburgh* (Oxford Clarendon Press, 1976), Arnold Thackray, "Natural Knowledge in Cultural Context The Manchester Model," *American Historical Review*, 79 (1974), 627-709, and Robert Kargon, *Science in Victorian Manchester Enterprise and Expertise* (Baltimore Johns Hopkins University Press, 1977) all touch upon the broader movement in different ways

from the 1830s to the early 70s, and rapidly escalated thereafter Thus, a rough count of private and public collections in natural history and antiquities shows that while twelve collections were founded in the 1850s and sixteen in the 1860s, twenty were founded in the 1880s and thirty-five in the 90s.[2] Art holdings aside, the majority of collections were in local and natural history, with British archeology and antiquities somewhat less numerous. Collections in anthropology (both physical and cultural) and in medicine were less common

Like the great national foundations, local museums were established as institutional receptacles for the donations of private collectors The wide pursuit of natural and local history produced private cabinets composed of everything from British archeological specimens to lepideoptera [3] An established pattern of philanthropy channelled private initiative into public profit, where municipal boards and corporations received possession of private collections upon the provision of adequate public housing for them [4] The Liverpool Public Museum was just such a product, built upon two major donations — the Derby Natural History Collection and the Mayer Archeology and Ethnology Collection — given to the corporation in the early 1850s and 60s Later departments were established around new collections, added as the museum grew in size and scope The popularity of the Museum Movement as a whole should not be underemphasized Almost a quarter million visitors thronged the Liverpool Museum in 1851, its first year of operation, even though it opened only four days a week [5] Other Victorian establishments recorded similar figures, making the new museums possibly the most successful centers for popular scientific education in the kingdom The great gothic and neo-classical halls erected to house them reflected civic assurance that patronage of natural knowledge lent prestige and culture to the supporting municipal corporations

[2] This data is drawn from Edmund V Corbett, ed , *The Libraries, Museums and Art Galleries Year Book, 1964* (London James Clarke, 1965) It lists collections rather than museums As many museums combined two or more collections, the total number of museums established is less than the absolute figures A more contemporary source, *The Museums Directory*, compiled by the Museums Association in 1902, lists a large number of collections not covered by the later *Year Book* It includes 150 collections in natural history, sixty-one in local history, fifty-seven in archeology and British antiquities, fifteen in anthropology, and sixteen in medicine The discrepancy in numbers is due both to inclusion of private collections not covered in the *Year Book* of sixty years later, and to the dissolution of small and ephemeral collections that did not achieve lasting support Many collections were also probably consolidated *The Directory* does not list foundation dates

[3] Many collections later formed the basis for professional scientific careers For example, see W H Flower, "Boy's Museums" in *Essays on Museums* (London Macmillan, 1898), pp 63-69

[4] This was the basis for the organization of much of the British Museum See Gavin de Beer, *Sir Hans Sloane and the British Museum* (London Oxford University Press, 1953)

[5] Liverpool Public Library and Museums, *Library and Museum Reports, 1853* (Liverpool n p , 1853)

J Edward Gray, Keeper of the British Museum's Zoological Department, had articulated a two-fold purpose for such public museums in 1864 It included, "1st, the diffusion of instruction and rational amusement among the mass of the people; and 2nd, to afford the scientific student every possible means of examining and studying the specimens of which the museum consists "[6] Gray espoused meeting this two-fold goal by organization of the collections into two parts The first was a collection exhibiting a limited number of interesting and representative examples of natural objects or artifacts for general educational purposes The second was a distinct and greater collection, where scientists could examine a multitude of similar specimens in order to ascertain minute differences and similarities

> What the largest class of visitors, the general public, want, is a collection of the more interesting objects so arranged as to afford the greatest possible amount of information, in a moderate space, and to be obtained, as it were, at a glance On the other hand, the scientific student requires to have under his eyes and in his hands the most complete collection of specimens that can be brought together, and in such condition as to admit of the most minute examination of their differences, whether of age, or sex, or state, or of whatever kind that can throw light upon all the innumerable questions that are continually arising in the progress of thought and opinion
>
> (J Edward Gray, p 76)

The creation of dual collections, or what W. H. Flower would later call the "new museum idea," came to form the organizational basis of many of the larger museums established during the Museum Movement Scientific curators first introduced it into the great national collections in London, from which other institutions borrowed the idea. This recognition of the museum as a center both for public education and for scientific research defined its functional orientation during the Victorian era.

Many smaller museums never attempted to form dual collections or meet the second of Gray's two objectives Their limited facilities and resources precluded serving any ends other than local education Other museums served as laboratories and research centers, particularly in natural history and archeology, while fulfilling their appointed tasks as centers for popular education and edification However, there were exceptions to the rule, where scientific and educational collections were combined into one and served both ends The overriding classificatory and ideological interests of their founders dic-

[6] J Edward Gray, "Address to Section D," *Report of the British Association for the Advancement of Science*, 34 (1864), 76

tated that they serve functions beyond those that Gray had outlined earlier. Probably the most interesting and important examples of this alternative mode were the museums of local history and anthropology established by General Augustus Pitt-Rivers in the 1870s and 80s.

II

General Augustus Pitt-Rivers (1827-1900) is one of the most interesting figures in nineteenth-century British anthropology and archeology. Born Augustus Lane Fox in 1827, he assumed his later name upon inheriting the estates of his great-uncle, George Pitt, the second Baron Rivers, in 1880. Educated at Sandhurst and commissioned in the grenadier guards in 1845, Pitt-Rivers was eventually made Honorary Lieutenant General in 1882. In 1867 he went on half-pay and devoted the rest of his life to the study of cultural anthropology and British archeology. He was elected a Fellow of the Royal Society in 1876, vice-president of the Society of Antiquaries in 1871, president of the Anthropological Institute in 1881-82, and first inspector of ancient monuments after passage of the Ancient Monuments Preservation Act in 1882.[7] Pitt-Rivers played an important and active role in the British Association, the Archeological Institute, and in the organization of the Anthropological Institute in 1871.

Early in his military career, Pitt-Rivers engaged himself in investigation of the use and improvement of the rifle, which had been introduced not long before into army use. He was instrumental in founding the Hythe school of musketry, and also carried on research at the Woolwich Arsenal, at Enfield, and in Malta between the years of 1851 and 1857. These studies proved decisive in directing his attention to the avocation which later became his life's work. Analysis of the processes of innovation whereby rifles were modified and made more effective interested Pitt-Rivers in the general processes of evolution and improvement in material culture. Henry Balfour, later curator of the

[7] For a short and sketchy biography of Pitt-Rivers, see M. W. Thompson, *General Pitt-Rivers, Evolution and Archaeology in the Nineteenth Century* (Bradford-on-Avon: Moonraker Press, 1977). See also Harold St. George Gray, "A Memoir of Lieut.-General Pitt-Rivers," in an *Index to 'Excavations in Cranborne Chase' and King John's House, Tollard Royal*, privately printed, 1905, pp. ix-xxvi.

Pitt-Rivers Museum at Oxford, succinctly described this turning-point in Pitt-Rivers' career.

> During his investigations conducted with a view to ascertaining the best methods whereby the service firearms might be improved, at a time when the old Tower musket was being finally discarded, he was forcibly struck by the extremely gradual changes whereby improvements were effected He observed that every noteworthy advancement in the efficiency, not only of the whole weapon, but also of every individual detail of its structure, was arrived at as a cumulative result of a succession of very slight modifications, each of which was but a trifling improvement upon the one immediately preceding it Through noticing the unfailing regularity of this process of gradual evolution in the case of firearms, he was led to believe that the same principles must probably govern the development of the other arts, appliances, and ideas of mankind [8]

It was to prove and demonstrate these principles of material evolution that Pitt-Rivers began to collect large numbers of human artifacts, commencing with weapons and expanding to include modes of navigation, objects of art and ornamentation, pottery, tools, religious implements, and clothing From his collecting resulted a developed theory of evolution in material culture and the contents of two museums — the well-known collection of ethnological artifacts which formed the basis of the Pitt-Rivers Museum at Oxford, and a smaller museum of anthropology and of agricultural and local history at Farnham in Dorset Both were organized along similar lines, and carried the same message of evolutionary progress among the material arts to different audiences.

Pitt-Rivers defined his goal as following (in Spencerian terms) the succession of ideas by which the mind of Man "developed from the simple to complex, and from the homogeneous to the heterogeneous" (Pitt-Rivers, "Evolution of Culture," p. 29) The artifact represented in concrete form an idea or conjunction of ideas which, having been expressed, maintained its shape and served as evidence of the condition of the state of culture at the time of its fabrication. Contemporary prehistorical excavations showed that the deeper the researcher delved into the remote antiquity of human history, the more simple became the products of human artifice. The work of Boucher de Perthes, Sven Nilsson, and others had periodized human history into epochs characterized by the increasing sophistication of technology.[9] Pitt-Rivers

[8] Henry Balfour, "Introduction," to Augustus Pitt-Rivers, *The Evolution of Culture and Other Essays*, J L Myres, ed (Oxford Clarendon Press, 1906), p v This is the best and largest extant collection of Pitt-Rivers' essays It includes "Principles of Classification," pp 1-19 (originally published in 1874), ' On The Evolution Of Culture," pp 20-44 (1875), "Primitive Warfare, Part I," pp 45-88 (1867), "Part II," pp 89-143(1868), Part III," pp 144-185 (1869), "Early Modes of Navigation," pp 186-232 (1874) All further references to these essays will be drawn from this volume

[9] See Jacob Gruber, "Brixham Cave and the Antiquity of Man," in Regna Darnell, ed , *Readings in the History of Anthropology* (New York Harper and Row, 1974), pp 380-406

concluded that the process of invention revealed was a slow one, and "aboriginal man, closely resembling the brutes, may have passed through many generations before he began to show even the first symptoms of mental cultivation, or the rudiments of the simplest arts, and even then his progress may have been, at first, so slow, that it is not without an effort of imagination that the civilized races of our day can realize, by means of the implements which he has left us, the minute gradations which appear to mark the stages of his advancement "[10] Using criteria of comparative relative homogeneity and simplicity to chronologically order similar sets of artifacts, the researcher could establish a sequence of material objects which displayed the progress of culture from the more to less primitive

Large gaps, however, were left in the record established by the surviving material remains of prehistoric cultures Objects made out of cloth and wood had entirely disappeared, leaving behind only implements of stone, clay, and metal; and, even these were incomplete. Nevertheless, the doctrine of the unequal progress of races allowed Pitt-Rivers to fill in the gaps. It was held by Pitt-Rivers and many of his contemporaries that the state of civilization — as typified and crowned by Victorian Britain — was an achievement of which only the Caucasian race was capable [11] Pitt-Rivers argued that the growth of culture among the great majority of peoples had been arrested and fossilized at different points in the development process Environmental conditions and unknown factors inherent within their racial make-ups led to a cessation of the creative and borrowing impulse by which a culture continued to progress The cultural level at which this growth was arrested persisted into the present age As a consequence, the material artifacts which were employed by different peoples were representative of varied stages in the unilinear path of cultural development. Different stages of development were locatable within different contemporary cultures, artifacts of which could be abstracted

[10] Pitt-Rivers, "Primitive Warfare, Part I," p 48 Pitt-Rivers particularly drew upon Herbert Spencer's *Principles of Psychology* (1st ed , 1855) and *Principles of Sociology* (1877-1896) in his own theoretical development

[11] Pitt-Rivers, "Primitive Warfare, Part I," p 49 The question of whether non-Caucasian peoples could achieve civilization under the influence of European tutelage was a matter of debate among anthropologists Pitt-Rivers appeared to believe that it was unlikely, E B Tylor, on the other hand, took a more hopeful view, see his *Primitive Culture* (London John Murray, 1871), I, chap 1 For a more complete discussion of the tenets of social evolutionism, see, among others, Marvin Harris, *The Rise of Anthropological Theory* (New York Thomas Crowell, 1968), especially pp 142-179, George Stocking, "Matthew Arnold, E B Tylor, and the Uses of Invention," and "The Dark-Skinned Savage The Image of Primitive Man in Evolutionary Anthropology," in *Race, Culture, and Evolution* (New York Free Press, 1968), J W Burrow, *Evolution and Society, a Study in Victorian Social Theory* (Cambridge Cambridge University Press, 1966)

and combined, along with prehistoric implements, to form a complete record of evolution in the material arts.

Man's earliest technology was in defensive and offensive weaponry, a technology which he copied from animals Weapons later found dual usage as tools, forming the basis for subsequent creations in material culture. The condition of ancient Man was

> one of such complete inanity as to render him incapable of spontaneously initiating even the most rudimentary arts, and it follows as a matter of course that in the earliest stages of his career, he must, like children of our own day, have been subject to compulsory instruction And in looking to nature for the sources from which such early instruction must have been derived, we need not, I think, be long in coming to the conclusion, that the school of our first parent must be sought for in his struggles for mastery with the brute creation, and that, consequently, his first lessons must have been directed to attaining proficiency in the art of war Hence it follows that it is to the lower animals that we must look for the origin of all those branches of primitive warfare
>
> (Pitt-Rivers, "Primitive Warfare, Part I," p 55)

Pitt-Rivers cited the reported use of stones as weapons by apes as the probable prehistoric inspiration for human weapon use [12] Aboriginal Man's most important attribute was his developed imitative faculty, through which he was able to copy nature for his own benefit. Taking up the use of stones as a weapon, he later added stick and ribbon slings to help improve their propulsion The stone itself, as with later weapons, was adapted to use as a tool, when some chance accident produced a sharp edge which served as the functional basis of what became the spear, pick, and dagger (Pitt-Rivers, "Primitive Warfare, Part II," p 104). Later weapons, such as serrated swords, were imitations of the claws and teeth of animals, while body armor originally was a human imitation of animal hide (Pitt-Rivers, "Primitive Warfare, Part I," p. 59 ff)

Pitt-Rivers never elaborated a complete theory on the development of material culture His anthropological essays and addresses primarily dealt with the evolution of weapons and early modes of navigation, extending to other areas of material culture where the latter could be clearly seen as offshoots from the former. He did emphasize, however, the primacy of weaponry as the basis for later cultural invention. Imitation of nature was the origin of art and technology. To survive in nature, aboriginal Man copied from his environment, using the weapons of his competitors against them Over the aeons, slow

[12] Augustus Pitt-Rivers, 'Hand Stones and Slings," in *Catalogue of the Anthropological Collection Lent by Colonel Lane Fox for Exhibition in the Bethnal Green Branch of the South Kensington Museum*, June 1874 (London Science and Art Department of the Committee of Council on Education, 1874), pp 156-163

adaptation of weaponry to other ends formed the basis for the non-martial arts (see "Primitive Warfare, Parts I-III") Armor transmuted itself into clothing, clubs into paddles. Pitt-Rivers' writings and collections suggested a research program for nineteenth-century anthropologists, rather than a completed study Thus it was that Pitt-Rivers viewed his museums as laboratories where both anthropological science and human history could be elaborated

III

Pitts-Rivers believed his collections possessed a significance which was greater than their demonstration of the path of evolution in technology, although that was an achievement to which he credited great importance By extension, he argued that the technological evolution demonstrated within the collections served also to illustrate the workings of development in human culture as a whole The mechanics of evolution were the same across nature and culture; only the final product varied. Through the use of analogical reasoning, both the scientist and the simple observer, by reading from the book of genesis in material culture, could see the course of evolution traced in the development of human institutions This Pitt-Rivers saw as the central significance of his ethnological collection Writing to E B Tylor in 1883, he disclosed that:

> If I were going to lecture about my collection, I should draw attention to the value of the arrangement not so much on account of the tools, weapons in themselves, but because they best serve to illustrate the development that has taken place in the branches of human culture, which cannot be so arranged in sequence because the links are lost and the successive ideas through which progress has been effected have never been embodied in material forms, on which account the Institutions of Mankind often appear to have developed by greater jumps than has really been the case But in the material arts, the links are preserved and by due search and arrangement are placed in their proper sequence The psychological continuity can therefore be better demonstrated by means of them than by means of the Institutions and Religions of Mankind They should therefore serve as a preliminary study for the Anthropologist who will by that means have to appreciate the gaps that are to be found in the latter and avoid the errors which the apparent absence of continuity may in some cases engender, and show how in studying the Institutions of Mankind those missing links must be supplied by conjecture which in the material arts can be arranged in rows so obvious that those who run may read [*sic*] [13]

Human society and its constituent institutional building blocks were the product, Pitt-Rivers believed, of a slow developmental

[13] Augustus Pitt-Rivers to E B Tylor, 5 July 1883, Pitt-Rivers Papers, Blackmore Museum, Salisbury

process that was one of a kind with that which he observed in his studies of material culture. Slow incremental change had produced the structure of the state, of language, of religion, of the family and social organization as it was experienced both in contemporary Britain and elsewhere. This law of movement from simplicity and homogeneity to complexity and heterogeneity was a universal, common, as Spencer had shown, to all nature "We see at once that there are not several kinds of evolution having certain traits in common, but evolution going on everywhere after the same manner setting out with the human body as a minute part, and ascending from it to greater parts, this simultaneity of transformation is equally manifest — that while each individual is developing, the society of which he is an insignificant unit is developing too; that while the aggregate mass forming a society is becoming more definitely heterogeneous, so likewise is that total aggregate, the Earth, of which the Society is an inappreciable portion."[14]

E B Tylor most successfully used the idea of evolution to study the development of human society Tylor, the foremost anthropologist of his time, unlike Spencer limited his efforts to the development of a science of culture, arguing that

> the philosophy of history at large, explaining the past and predicting the future phenomena of man's life in the world by reference to general laws, is in fact a subject with which, in the present state of knowledge, even genius aided by wide research seems hardly able to cope Yet there are departments of it which, though difficult enough, seem comparatively accessible If the field of inquiry be narrowed from History as a whole to that branch of it which is here called Culture, the history, not of tribes or nations, but of the condition of knowledge, religion, art, custom, and the like among them, the task of investigation proves to lie within far more moderate compass [15]

While Tylor concentrated his attention upon tracing the history of institutions, Pitt-Rivers attempted to elucidate the development of the material aspects of cultures [16] A careful reconstruction of the processes

[14] Herbert Spencer, *First Principles of a New System of Philosophy*, 2d ed (New York D Appleton & Co , 1868), pp 545-546

[15] E B Tylor, *Primitive Culture Researches into the Development of Mythology, Philosophy, Religion, Art, and Custom*, 2 vols (London John Murray, 1871), p 5 It was the gift of Pitt-Rivers' ethnological collection to Oxford that was responsible for Tylor's appointment by that University to Keepership of the University Science Museum in 1883, and to a lectureship in anthropology in 1884 Part of the original deed of gift stipulated the appointment of a curator for the collection by the University George Rolleston and H W. Acland talked Pitt-Rivers into changing this into a requirement for an anthropological lecturer, creating a position for Tylor

[16] This is not to argue that Tylor lacked interest in or did not write upon material culture, or that Pitt-Rivers was not interested in the evolution of institutions The central focus of Tylor's work was upon institutions, however, with material culture being Pitt-Rivers' particular area of expertise Tylor's breadth of interest and knowledge was certainly more extensive than Pitt-Rivers' was

of evolution in technology would help establish by analogy the more important development pattern for human institutions

Tylor and Spencer were both influential upon Pitt-Rivers' thought and writings. He quoted them in his essays on material evolution, and was especially prone to use Spencerian terminology in his description of general and specific evolutionary processes Nevertheless, the most important influence and source for his own intellectual development lay within the field of prehistoric archeology, that specialty where the majority of his own work was centered

Pitt-Rivers is best remembered today for his archeological work in the barrows and earthworks of southern England His precise stratigraphic field methodology helped establish the science of archeological excavation and preservation The majority of Pitt-Rivers' published work was upon archeological topics, culminating in his *opus magnus*, *Excavations in Cranborne Chase*, published in five volumes between 1887 and 1905 [17]

Pitt-Rivers did his first archeological fieldwork in Ireland, after being posted there as Assistant Quartermaster General in 1862. His first excavation was upon an earthwork at Roovesmore Fort in 1865, an undertaking soon succeeded by similar work in both Ireland and England. He worked with Canon Greenwell, the noted excavator of British barrows, in 1867, and subsequently undertook a study of prehistoric hill forts in Sussex.[18] In 1869, in an important discovery, Pitt-Rivers unearthed human paleolithic artifacts in drift gravel at Acton, in the Thames river valley above London. This was the first such discovery in the upper Thames. He later (1872) found remains of *Elephas primigenius* in the same deposits [19]

Through his discoveries, Pitt-Rivers duplicated in kind the earlier work of Boucher de Perthes (from 1847) at Abbeville in France, and of Hugh Falconer, William Pengelly, and Joseph Prestwich at Brixham Cave in Devon in 1858 (Gruber, "Brixham Cave"). All of their discoveries, supported by the concurrence of John Evans and Sir Charles Lyell, were decisive in establishing the remote antiquity for

[17] Augustus Pitt-Rivers, *Excavations in Cranborne Chase, Near Rushmore, on the Borders of Dorset and Wilts*, 5 vols , privately printed, 1887-1905.

[18] Augustus Pitt-Rivers, "An Examination into the Character and Probable Origin of the Hill Forts of Sussex," *Archaeologia*, 42 (1868), 27-52, "Further Remarks on the Hill Forts of Sussex Being an Account of the Excavations in the Forts of Cissbury and Highdown," *Archaeologia*, 42 (1868), 53-76

[19] Harold St George Gray, "A Memoir of Lieut -General Pitt-Rivers," in Pitt-Rivers, *Excavations in Cranborne Chase*, V, ix-xxxvi, xviii

mankind in Europe Pitt-Rivers was to say of his own researches at Acton that

I was able in 1872 to show by means of plans and sections the exact analogy of the palaeolithic site there with that of the valley of the Somme, near Amiens and Abbeville Other similar discoveries have since been made in the valley of the Exe and elsewhere in this country The nature of the implements found in these gravels was such as to fully bear out the doctrine of evolution, being characterized by extreme simplicity as compared with the stone implements of a later date, and they introduce us to a condition of the arts of man, in which a simple flake or a flint held in the hand at one end and trimmed to a point at the other, appears to have afforded the most advanced idea of a general tool for all the purposes of life, so that the palaeolithic or earliest form of implements can be everywhere distinguished by their simplicity from the neolithic or stone implements of a later date, and they are more or less the same in all the localities in which they have been found [20]

The origin of Pitt-Rivers' conclusions on the evolution of material culture can be traced to a combination of his earlier work on the development of firearms and the broader deductions he drew from the discoveries of contemporary prehistorical research Tyler and Spencer helped provide the theoretical framework and language in which Pitt-Rivers then framed his thought.

Pitt-Rivers demonstrated technological evolution through the use of what he termed sequences of type, or "typologies." He argued that in an educational museum, specimens should be selected and displayed so as to show sequence, or how, developmentally, one form led to another Where the dates of objects were known, then arrangement must be in terms of chronological order. But in the case of the majority of prehistoric objects, and also of many of the arts of primitive peoples, chronology could be only guessed at In these circumstances, typology must be relied upon:

It supplies the want of dates by showing how certain forms must have preceded or followed others in the order of their development, or in the sequence of their adoption It may be said, as a rule, that simple forms have preceded complex ones Within certain limits this must be true, but it is not always the case, for, in many instances, progress consists in eliminating superfluous complexity, and reducing the expenditure of time and labour It is the work of typology to unravel the true thread of events, and place the objects in their proper sequence for the use of students Typology forms a tree of progress, and distinguishes the leading shoots from the minor branches [21]

Pitt-Rivers organized his typological series through classification by form, such as differently represented in the spear, bow, club, etc

[20] Augustus Pitt-Rivers, "Inaugural Address of Lieut -Genl A H Lane-Fox Pitt-Rivers to the Annual Meeting of the Institute Held at Salisbury," *Archaeological Journal*, 44 (1887), 261-277, see pp 273-274 for the quote

[21] Augustus Pitt-Rivers, "Typological Museums, as Exemplified by the Pitt-Rivers Museum at Oxford, and his Provincial Museum at Farnham, Dorset," *Journal of the Royal Society of Arts*, 40 (1891), 116

Within each of these classes, sub-classes were created for special localities. Within the sub-classes, wherever possible, specimens were arranged according to their affinities, with the simpler on the left, and successive improvements in a line to the right (Pitt-Rivers, "Principles of Classification," p. 3). "Wherever amongst the implements or other objects exhibited in a given series there seemed to be suggested a sequence of ideas, shedding light upon the possible stages in the evolution of this particular class, these objects were specially brought into juxtaposition. As far as possible the seemingly more primitive and generalized forms — those simple types which usually approach most nearly to natural forms, or whose use is associated with primitive ideas — were placed at the beginning of each series, and the more complex and specialized forms were arranged towards the end" (Balfour, "Introduction," p. v).

Henry Balfour concluded of Pitt-Rivers' Oxford collection that the primary object of its classification by series was to demonstrate either actually or hypothetically, "the origin, development, and continuity of the material arts, and to illustrate the variations whereby the more complex and specialized forms belonging to the higher conditions of culture have been evolved by successive slight improvements from the simple, rudimentary and generalized forms of a primitive culture" (Balfour, "Introduction," pp. vi-vii). The role of a curator like Balfour was to fill in the typologies and to create new ones as artifacts became available. The typologies as educational instruments were otherwise self-sufficient. They demonstrated sequence, increasing complexity, and progress to even the most casual observer. The cramming of large numbers of artifacts into display shelves closely illustrated the sequence of development within material culture.[22]

IV

Pitt-Rivers developed two separate collections of artifacts which he arranged into evolutionary sequences. The first and largest eventually formed the nucleus of the Pitt-Rivers Museum at Oxford; the second was brought together within the museum of anthropology and local history which he established on the grounds of his country

[22] Pitt-Rivers literally packed his display cases with large numbers of functionally related artifacts to illustrate both the sequence of development and the production by different cultures of similar artifacts. This was a pedagogic device in specimen display that has been maintained at the Pitt-Rivers Museum.

estate in Farnham, Dorset. Both collections were organized typologically and had strong educational motifs. Their settings and prospective audiences were disparate, however Pitt-Rivers' ethnological collection, the basis of the Pitt-Rivers Museum, consisted of the bulk of his collecting from 1851. Pitt-Rivers had started collecting primitive weapons during his military career, and extended his acquisitions to include other aspects of culture as his interest in material evolution developed (see Pitt-Rivers, "Typological Museums," p 118). The scope of his purchasing rapidly increased after he came into his inheritance in 1880 The collection was housed in Pitt-Rivers' London home until 1874, when it went on loan to the Bethnal Green Branch of the South Kensington Museum In 1879 the collection moved to larger rooms in the West Galleries of the South Kensington Museum It was subsequently offered to Oxford University in 1883, and moved to its new quarters, the Pitt-Rivers Museum, in 1885 [23]

Prior to its donation to Oxford, Pitt-Rivers had negotiated with the Trustees of the British Museum over the collection's accommodation at that institution. Space was limited at South Kensington and stood in the way of continued expansion of Pitt-Rivers' series Pitt-Rivers also felt that the collection's proper place was within the British Museum, where it would be an important educational adjunct to the geographically organized ethnological collections.[24] However, the Trustees turned down Pitt-Rivers' offer on the grounds of the striking variance in the method of exhibition and on his demand that he should retain control over the collection during his lifetime. Both the South Kensington and British Museums could offer Pitt-Rivers access to large audiences. Hence, they had appeal as centers for exhibition of a collection whose *raison d'etre* was education. Oxford offered much smaller audiences, but it alternatively promised a central position within the developing sciences division of the nation's oldest and most important university.[25]

During its exhibition at Bethnal Green and South Kensington, the collection essentially consisted of four parts. There was a collection of photographs representing various races, along with a small series of

[23] The collection was not opened to the public until 1887, however See note in *Nature*, 35 (10 February 1887), 349

[24] Augustus Pitt-Rivers to A W Franks, 1 July 1880, Miscellaneous Papers on Pitt-Rivers Museum, Balfour Library, Oxford Pitt-Rivers had also offered the collection to the South Kensington Museum in April of 1880, but it was rejected there on similar grounds, Great Britain House of Commons, "Pitt-Rivers Collection," *Accounts and Papers*, 73 (1881), 519-524.

[25] The Pitt-Rivers Museum was built as an adjunct to the University Science Museum, where the majority of science laboratory space and teaching was centered

skulls which exhibited well-marked racial characteristics [26] A second part consisted of a collection of weapons which demonstrated their functional evolution The third division illustrated the development of musical instruments, ornaments, and designs. The last division was concerned with the development of utensils, houses, ships, and all other varieties of human implements and utensils One series of artifacts which was used to illustrate the origin of weaving contained specimens of bark cloth of naturally interconnected fibers, spindle-whorls from all over the world, primitive looms, and so on. The series on the origin of clothing commenced with body ornamentation — the basis for much of the later developments in clothing — and went on through displays of natural loin cloths, paper cloth, grass dresses, and skin coats. The other series were similarly comprehensive.

The collection as it reached Oxford included more prehistoric weapons and instruments and had a greater number of objects associated with domestic life, the art of writing, and religion [27] It contained a greater number of series, with more objects in each series There had been a steady internal development of the collection, from one with an emphasis upon the evolution of weaponry to one detailing the evolution of a majority of the domestic and material arts Over 14,000 objects were contained in Pitt-Rivers' gift to the University.

The museum at Farnham, Dorset, contained a collection organized on a much lesser scale and oriented to a much different audience. While the Pitt-Rivers ethnological collection had first served as an educational tool directed at a popular metropolitan audience, and then as a teaching and research aid in a university center, its parallel in Farnham was located in a small country parish boasting a population of only 301 in the early 1890s (Pitt-Rivers, "Typological Museums," p 119). The museum was organized to serve the surrounding agricultural population, along with residents of nearby towns.[28] There consequently was a dearth of casual visitors, and the museum needed to attract spectators to its out-of-the-way location. Pitt-Rivers' solution to this problem was development of a museum of local history organized along typological lines, with adjacent pleasure

[26] "General Pitt-Rivers' (Lane Fox) Anthropological Collection," *Nature*, 22 (23 September 1880), 489-493, 511-515

[27] "The Pitt-Rivers Collection," *Oxford University Gazette* (6 February 1883), p 295

[28] For discussions of the Farnham Museum, see Augustus Pitt-Rivers, *A Short Guide to the Larmer Grounds, Rushmore, King John's House, and the Museum at Farnham, Dorset* (London privately printed, 1894), L H Dudley Baxter, ed , *Pitt-Rivers Museum, Farnham, England General Handbook* (Farnham The Museum, 1929)

grounds on his country estate at Cranborne Chase (Pitt-Rivers, "Typological Museums," pp. 119-120)

The museum itself was in a two-story brick building divided into eight rooms [29] It was filled with agricultural implements and peasant handicrafts, along with illustrations of their historical antecedents from around the world. Important series included those on pottery, peasant costumes and personal ornaments, agricultural tools, and household utensils The developmental history of locks and keys was shown, as was the history of glass and enamels. The results of Pitt-Rivers' archeological excavations at Cranborne Chase were also deposited at the museum. But the center of emphasis was upon the evolution of peasant life, as shown in its material culture.

Pitt-Rivers did not feel that an emphasis upon those arts and crafts which were of day-to-day importance to his hoped-for visitors would be sufficient to draw them to Farnham He consequently fenced it around with other diversions which would draw agricultural laborers and townspeople alike (Pitt-Rivers, "Typological Museums," pp. 119-120) Nearby to the museum he opened a recreation ground, called the Larmer Grounds, on his estate lands Access to the property was free to the public. Tables and benches were erected, and refreshments sold at small cost Pitt-Rivers formed a private band to play to his guests, and eventually added decorative buildings, a singing stand, dining hall, and golf links to the property A hotel was built for the better class of visitors All served to attract visitors who might then be edified and instructed·

> A pretty country, a pleasant drive in their country carts, an attractive pleasure ground, a good band, and lastly a museum, are the means which I have found successful, and which I am justified in recommending to those who wish to draw the people out of the towns into the country If no more good came of it than to create other interests, which would draw men's minds away from politics, that greatest of all curses in a country district, good would be done If only a more scientific knowledge of the arts of life, and of the laws of nature affecting the development of those industries by which the working classes gain their living, the results would be beneficial [*sic*]
>
> (Pitt-Rivers, "Typological Museums," p 120)

Pitt-Rivers saw the beneficial by-products of museum instruction as being more than simple education and edification of the masses. Museums, if properly organized, would teach history, and a knowledge of history among the general populace should have measur-

[29] M W Thompson, *General Pitt-Rivers*, pp 79-85, Pitt-Rivers, "Typological Museums", "Obituary Notice for Lieut -General A H Lane Fox Pitt-Rivers," *Archaeological Journal*, 57 (1900), 174-179

able political and social consequences. In Pitt-Rivers' eyes, history as taught by social evolution was an applied science.

V

Pitt-Rivers' museums possessed an ideological dimension that extended beyond their surface concentration upon science and public pedagogy. The model of evolution that Pitt-Rivers espoused included a unitary evolutionary process that functioned similarly in different contexts The growth from simplicity to complexity and from homogeneity to heterogeneity similarly described the evolution of the universe and that of the social state. It was as a consequence of this law that a collection illustrating development in material technology could be presented as being equally demonstrative of wider institutional evolution; the functional processes of change were the same in both. If this were true for material and institutional change, so must it also be true for specifically political change. Thus, the argument by analogy extended itself into the political or ideological sphere. The museum could become a means for elucidating and directing the process of social and political evolution

Pitt-Rivers was an active member of the Conservative Party, and at one point offered himself as a candidate for his local Tory parliamentary nomination. Nevertheless, his Conservatism was of a variety which might have made him a Peelite earlier in the century He viewed social change as something to be directed and limited, not striven against:

> The student of science can be neither exclusively Liberal nor exclusively Conservative He is bound to apply both principles in their proper places He must be Conservative in the sense of recognising that it is only by preserving the root, the stem, and the branches of our social system as it now exists that civilization can be expected to bring forth its periodical shoots of progress He must be Liberal in desiring that those periodical shoots may be left to flourish and adjust themselves in the free air and light of Nature, unfettered by oppressive laws and over legislation [30]

A successful Toryism, in his view, would serve the country by accepting necessary change and absorbing it into the established system. It was saltatory, disruptive development that was to be feared. Evolution was a natural and human law; revolution was a cataclysm which was socially destructive.

[30] Augustus Pitt-Rivers, *An Address Delivered at the Opening of the Dorset County Museum, on Tuesday, January 7th, 1884* (Dorchester James Foster, 1884), p 15

Pitt-Rivers was not atypical among Victorian anthropologists in discovering confirmation of his political and social beliefs among primitive peoples. His work and writings simply demonstrate these connections more clearly than do those of his contemporaries. E. B Tylor's description of anthropology as a "reformer's science" implicitly demonstrates his view that the culture of primitive peoples was a resource whose analysis would serve to isolate those remnants of ancient superstition which, surviving into modern civilization, should be eliminated On the opposite political pole, it can be argued that Henry Sumner Maine utilized his studies of the development of property right and contract as a defense for the prevailing system of land tenure and property holding in Western capitalist states. The lessons taught by anthropology were capable of being used to argue for or against specific social theories, depending on the interests of the social theorist

Pitt-Rivers was arguing for political gradualism and moderation in a period of chronic unrest and economic difficulties The years from 1873 to 1896 have been commonly labelled as the Great Depression by economic and social historians [31] They included a marked decline in economic prosperity, with several relatively deep, short-lived depressions and increased unemployment, all alongside heightened political agitation. Increasing union militancy and radicalism as represented by the Social Democratic Federation seemed to confirm the fears of many in the middle and upper classes that events were getting out of control and that political liberalization had gone too far. The late 1870s to the mid-90s seemed to be a recasting of the Hungry Forties, with heightened class tensions, national and intra-party political disunity, and increased debate on the future of the nation and the empire

Pitt-Rivers, along with many of his contemporaries, was convinced that science could provide a bulwark against such disjunctive and abrupt change as appeared to loom on the horizon. Knowledge of natural law, of the necessity and rightness of gradualistic

[31] For studies of poverty and class relations in the 1870s and 80s, see Gareth Stedman Jones, *Outcast London A Study in the Relations Between Classes in Victorian Society* (Oxford Clarendon Press, 1971), E P Hennock, "Poverty and Social Theory in England The Experience of the Eighteen-Eighties," *Social History*, 1 (1976), 67-91, Anthony S Wohl, "The Bitter Cry of Outcast London," *International Review of Social History*, 13 (1968), 189-245 Michael S Helfand, "T H Huxley's 'Evolution and Ethics' The Politics of Evolution and the Evolution of Politics," *Victorian Studies*, 20 (1976-77), 159-177, argues that the political climate of the 1880s forced T H Huxley to recast his political stance and take an active role in the political affairs of the period, in reaction to the radical activities of Henry George and A R Wallace, among others

evolutionary change, would help prevent disruptive and destructive attempts at subversion of the natural order Science was a resource which could speak to the problems of the time. Natural and social law were intertwined, and the laying bare of one also uncovered the workings of the other.[32]

Thus, at a gathering of the Primrose League in Handley, Dorset, Pitt-Rivers expostulated to fellow Conservatives that "this is an age of science; progress in these days is to be looked for in the ranks of scientific men rather than in the Legislature. We should listen to what they have to tell us when they treat upon social evolution, as they see the affairs of the world from a much higher standpoint than political men who are merely wire pullers and partisans."[33] Scientists, among the ranks of whom Pitt-Rivers numbered himself, by their training were the nation's best social legislators Removed from the fray, their vision and judgment was more acute and objective than that of the laity, a point which Huxley echoed in his 1893 essay, "Evolution and Ethics" (see Helfand). Pitt-Rivers correspondingly concluded that

> it is to the spread of the scientific method of thought, and more particularly to the sciences of society to which I have referred, if to anything that we must look for relief from those pernicious doctrines which appear to be upon us like a pest in the form of undue State interference, socialism, limitations upon the freedom of contract, and perpetual change of the law Scientific opinion is based upon such broad induction that it is not amenable to party tactics It teaches men to suspend their judgment until sufficient evidence is obtained Science deprecates radical changes by showing how slow and gradual have been the steps by which all stable institutions have advanced, and that the motto "Natura non facet saltum" is as applicable to the progress of society as to the development of species
> (Pitt-Rivers, *An Address Delivered at the Opening*, p 14)

Nevertheless, the instruction of the population in the teachings and methods of the sciences would be a lengthy business Affairs were pressing, and the outcome of such instruction could not be patiently

[32] An interesting parallel to Pitt-Rivers' use of his organizational system as a social metaphor is carefully delineated by James Secord in "King of Siluria Roderick Murchison and the Imperial Theme in Nineteenth-Century British Geology," *Victorian Studies*, 25 (1981-82), 413-442 Murchison's Silurian system served as a means of enhancing his professional and social status, as well as Britain's international influence The extension of the Silurian system around the world was viewed by Murchison as an integral part of his efforts at encouraging British imperial development Pitt-Rivers' artifacts were collected from all over the world, including much of the British Empire But while Pitt-Rivers appears to have been a supporter of empire, I see no similar "imperial" theme in his classificatory system or collecting For discussion of anthropology and imperialism, see Talal Asad, ed , *Anthropology and the Colonial Encounter* (London Ithaca Press, 1973), Henrika Kuklick, *The Imperial Bureaucrat British Colonial Administration in the Gold Coast, 1920-1939* (Palo Alto, California Hoover Institution, 1978), "The Sins of the Fathers British Anthropology and African Colonial Administration," *Research in the Sociology of Knowledge, the Sciences, and Art* (November 1977), 93-120

[33] "Handley Primrose League Gathering," *Dorset County Chronicle*, 17 May 1888, a verbatim report of Pitt-Rivers' address to the League.

waited for Pitt-Rivers, however, appeared to believe that he had a temporary solution in the science museum The museum was immediate in its effect, graphically portrayed scientific knowledge, and was easily accessible to the public Anthropology (for Pitt-Rivers) was the science of culture, and to it must be entrusted instruction on the dynamics of how civilization was achieved and maintained. Nothing served better in this regard than collections of material culture arranged in educational typological series·

> The law that Nature makes no jumps, can be taught by the history of mechanical contrivances, in such a way as at least to make men cautious how they listen to scatterbrained revolutionary suggestions The knowledge of the facts of evolution, and of the processes of gradual development, is the one great knowledge that we have to inculcate, whether in natural history or in the arts and institutions of mankind, and this knowledge can be taught by museums, provided they are arranged in such a manner that those who run may read
>
> (Pitt-Rivers, "Typological Museums," p 116)

Pitt-Rivers' museums were organized so as to meet this goal His Oxford museum in particular served both as a scientific research center and as a tool for social education Although they could not stop social change, museums could help control and direct it through public education This explicit ideological dimension in the Pitt-Rivers museums was a function of the age in which they were constructed, and in many ways made them unique Yet, they served as examples to museologists and scientists alike as to how museum structures could have a potentially immediate impact on their social environment. A museum organized along evolutionary lines had the ability to turn abstract social theories into concrete accounts of human cultural and social development.[34] Pitt-Rivers' recognition of this fact, and his successful institutionalization of the idea within his own museum foundations, won him a position of some eminence among those of his contemporaries who similarly were struggling to incorporate the social reforms and changes of 1870s and 80s within the existing social and political framework of the nation.

Philadelphia

[34] Otis T Mason organized the anthropological collections of the U S National Museum in Washington along lines parallel to those found in the Pitt-Rivers Museum Franz Boas took issue with the classificatory method and with Mason in two articles in *Science* in 1887 ("The Occurrence of Similar Inventions in Areas Widely Apart" and "Museums of Ethnology and Their Classification" 9, [1887] 485-486, 587-589) Boas's attack was part of his overall opposition to the evolutionism then dominant in American anthropology Whether Boas's critique of Mason had at least a partial ideological dimension is not clear For a discussion of Boas's critique, see George Stocking, "From Physics to Ethnology," and "The Scientific Reaction Against Cultural Anthropology," in *Race, Culture, and Evolution*

Robert Louis Stevenson and *The Beach of Falesá*

A Study in Victorian Publishing

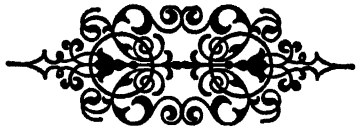
WITH THE ORIGINAL TEXT

Barry Menikoff One of Stevenson's finest achievements, *Falesá* ranks among the masterpieces of English novellas Yet until now, it has never appeared as it was written The printed version became to Stevenson "the slashed and gaping ruins" of his art, as the original text was systematically corrupted by friends, editors, publishers, and printers with deeply held Victorian political, sexual, and religious convictions The text of *Falesá*, faithfully transcribed from the original manuscript, is preceded by an analysis of what happens when a work of art is converted into a commodity to satisfy the tastes and prejudices of the period and a discussion of Stevenson's own role and responsibility in the process Illus About $28 50



Stanford University Press

BOOK REVIEWS



Yeats, by Douglas Archibald, pp xiv + 280 Syracuse Syracuse University Press, 1983, $25 00

W. B. Yeats and the Anti-Democratic Tradition, by Grattan Freyer, pp x + 143 Dublin Gill and Macmillan, 1981, Totowa, New Jersey Barnes and Noble, 1981, $22 50

Literature and the Changing Ireland, edited by Peter Connolly, pp viii + 230 Gerrards Cross, Buckinghamshire Colin Smythe, 1982, Totowa, New Jersey Barnes and Noble, 1982, $26 50

DOUGLAS ARCHIBALD TAKES FOR HIS TITLE THE ONE Harold Bloom used in 1970, and the echo, amidst an impressive range and depth of scholarship, is not accidental Like Bloom, Archibald is most concerned with influences, seeking to identify the "originals" of William Butler Yeats's thought and the processes by which they worked towards "ideal expression" (p xiv) It is an ambitious approach to a poet who, as Archibald says, "may have been more gifted and fortunate in devouring and converting influences than any other modern artist save Picasso" (p xii) Joyceans, and perhaps even Bloom, might disagree here Yet those moments in Archibald's work where the various originals and expressions crystallize — a poem, a letter to Lady Gregory, a passage from the *Autobiographies*, and the death of Mabel Beardsley — are truly brilliant

Like Bloom, Archibald sees Yeats operating, albeit uneasily, within the poetic tradition of the British Romantics, his opening chapter is a wonderful, self-contained comparison of "A Prayer for My Daughter" with Coleridge's "Frost at Midnight " The Romantics remain only one of many influences that Archibald considers, though More important to this study are Yeats's dialogues with friends and family Taking his analysis even further beyond the area that Bloom has explored, Archibald also tries to define the historical nature of Yeats's identity, the ways in which Yeats's imagination interacted with "the contingent moment" and Irish and European "social forces" as well as with individual personalities (p xii)

These more historical concerns, however, primarily discussed in the middle chapters that the dustjacket misleadingly terms the "heart of the book," are the least satisfying "Anglo-Ireland and Celtic Ireland" is a sketchy survey of Yeats's major role in the Irish literary revival and of his responses to Ireland's two main cultural traditions The chapter fills a biographical gap, but one that could have been ignored Elsewhere, the ghostly instructors of *A Vision* take on as much historical substance as Berkeley, Burke, or Swift Even the few typographical errors in the book seem concentrated in the middle

One senses that Archibald's heart lies outside a historicist approach, preferring instead to follow Yeats's emphasis on individual character The best discussions center around single poems held clearly in the foreground, governed by a sound critical judgment that traces various strands of the work back to passages from Yeats's letters and prose writings, his reading in philosophy or political theory, or his friendships with Maud Gonne, Lady Gregory, or J B Yeats The personality of Archibald himself, Colby College's Dean of Faculty, also emerges with engaging presence in many of the assessments His fine explication of *A Vision* does not fail to point out its occasional "penny-astrology prescriptions" or its game-like rules that "sound suspiciously like cosmic *Monopoly*" (p 192)

At the same time, Archibald shows how these very doctrines could be transformed into masterful poetry For Yeats, the "imaginative act" involved "seeking and conflict and defeat' as well as the recapturing of an earlier self as a compensation for loss (p 180) Intermingling past and present, his own imagination with those of the people that mattered most to him, in processes that seem organic, sexual, or religious, Yeats was constantly involved in the making and remaking of an allegorical self It is a major achievement that Archibald can show us so clearly these processes at work

Yeats's dialogue with Irish history, a minor concern for Archibald, forms the consistent focus of Grattan Freyer's shorter study, *Yeats and the Anti-Democratic Tradition* The title aptly forecasts Freyer's purpose tracing "the evolution of Yeats's political ideas and their interplay in the intellectual climate of his age"

(p 2) Freyer, the Director of the Irish Humanities Centre in Dublin, spends little time on the non-Irish or non-political influences on Yeats and thus produces a tightly organized and unified work He adds little that is new to the subject, and the book includes only a handful of footnotes plus opening references to perhaps a dozen of the main critical sources Yet Freyer's ability to write so engagingly about the Irish context, and to synthesize its many facets so smoothly, makes this a fine introductory overview of the historical background

Consistent with its synthetic style, the book argues for the continuity, in Yeats's life and thought, of the concept of the elite This began, for Yeats, in his earliest nationalism via John O'Leary Dominated politically and economically by England, Ireland still defined itself poetically with values hostile to British materialism, progress, and prosperity For his part, Yeats chose to emphasize the national, the individual, and the unique from his experience

So far so good Where this turns nasty, for Yeats scholars, is in his later attraction to fascism and such statements as this of December 1922 "Democracy is dead and force claims its ancient right" (p 94) His interest in the political possibilities of fascism lasted for over a decade and included an involvement with the Irish Blueshirts and sympathy for eugenic selection as a means of establishing a ruling elite Freyer's most significant chapters cover this difficult period He surveys several previous commentaries on Yeats s political philosophy, concentrating on Conor Cruise O'Brien's influential and controversial essay, "Passion and Cunning" (1965), and Elizabeth Cullingford's study, *Yeats, Ireland and Fascism* (1980), which seeks to refute O'Brien at every turn

As these two examples suggest, our responses to this side of Yeats depend finally on our own political assumptions Archibald has recognized this, and while he admires the strengths of Yeats's work from 1922 on, he also identifies the limitations, those parts that are "depressing" or "distressing," that are "frequently repulsive, often hysterical, sometimes self-parodic" (p 152) Freyer would have it otherwise, claiming that "the role of the critic is to explain rather than to judge" (p 2) Nonetheless, Freyer himself ends up somewhere between O'Brien and Cullingford and sees Yeats's vision of utopia as a not "altogether despicable ideal" (p 137) This is certainly true, and Freyer's explanatory terms like authoritarian, elitist, or anti-democratic are more useful than "Fascist " But inevitably, such terms do judge

One way out of this methodological thicket is offered by Stan Smith's excellent theoretical essay, "Historians and Magicians," in *Literature and the Changing Ireland* Using Jacques Lacan's psychological and Louis Althusser's historical theories on the construction of the human subject, Sr h regards history as "a mode of discourse i which we simultaneously discover and lose ourselves" (p 138) Language and history, signifier and signified, become inextricably mixed in the medium of our own ideologies Smith's approach seems particularly relevant to Ireland, with its literary emphasis on history as subject as well as its political emphasis on history as a living force still acted out in the Ulster conflict

Smith's essay is one of ten lectures from the 1979 conference of the International Association for the Study of Anglo-Irish Literature, held at Maynooth College The essays are arranged chronologically and, with a few exceptions that are also the weakest offerings, take up the subject of literature's response to and role in Irish historical change Cathal G Ó Háinle, for instance, discusses how the political context shaped various translations of Irish poetry and how those translations in turn affected later Irish writing in English Vivian Mercier's provocative and convincing analysis shows how Irish Evangelicalism set much of the shape and tone of the Literary Revival, from its spiritual concerns such as theosophy to its more practical strategies such as the usefulness of Gaelic as a means of "converting" a Catholic peasantry to the religion of art From this collection, these three essays are significant ones, and Mercier's especially should have a major impact on future assessments of modern Irish literature

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Man of Wars William Howard Russell of *The Times*, by Alan Hankinson, pp x + 304 London Heinemann Educational Books, 1982, £12 50, $25 00

WILLIAM HOWARD RUSSELL, "THE FIRST AND GREATEST of war correspondents," was the most famous journalist of the Victorian age A convivial man with a passion for club life and the Bohemian vices of gluttony and gambling, Russell's intimates included Charles Dickens, William Makepeace Thackeray, and the future King

Edward VII When he covered the Sepoy Mutiny or the Battle of Sedan for *The Times*, he did it in the style of a potentate with sufficient accouterments to meet the needs of ten ordinary men Yet, notwithstanding these slightly comic frailties, Russell's journalism cut deeply into the political life of his century His lengthy "descriptive letters" from a variety of battlefields were backed by the powerful leader columns of *The Times* during the Crimean War his dispatches helped to bring down the coalition government of Lord Aberdeen, and at an early stage of the American Civil War, his account of the collapse of the Northern army at Bull Run badly tarnished the image of the Union cause in Europe

Alan Hankinson's *Man of Wars*, a detailed biography of Russell, does justice to its fascinating subject, if in a somewhat old-fashioned way Hankinson makes effective use of Russell's voluminous diaries and published writings to present a rounded portrait of the man, minus a few telling warts He follows the interpretation of J B Atkins, the journalist's previous biographer (1901), in depicting him as a man of great narrative flair and consuming energy A personification of "Victorian man," Russell is characterized as honest, brave, and neutral in his coverage of events, as every good journalist should be With scarcely a touch of irony, Hankinson also commends his attacks (more inconsistent than he is willing to concede) on colonialism, racial prejudice, and war Metaphorically biting the hand that fed him, Russell lamented the brutalities of war, in which "thought for the dead was forgotten or unexpressed", at the same time, he frankly evoked war's physical and emotional glories

Man of Wars is strongest on the set pieces that established "Billy" Russell's reputation with a large reading public that had few scruples about the use of military power At Balaclava, in the Crimea, where he coined the immortal phrase "that thin red streak topped with a line of steel," to describe the defense of the 93rd Highlanders, he established his claims on posterity Modern war correspondents might experience twinges of jealousy at the thought of Russell watching the battle from atop a grassy knoll with a picnic hamper and a bottle of wine nearby and some aristocratic ladies to keep him company But he wrote with intensity, and his accounts of the battle were more widely read than those of any other military conflict during the nineteenth century At Bull Run (where he retreated on horseback along with the rest of the Northern army), things got more heated "A whole mass of infantry, with fixed bayonets, ran down the bank of the road, and some falling as they ran must have killed and wounded those among whom they fell " And at Koniggratz, alongside the Austrian army, Russell depicted "a scene in which every village was vomiting forth fire and smoke [and] every valley [was] the indiscriminate grave of thousands of men " Finally, while covering the mutiny in India, Russell almost died as the result of a kick from a horse "Naked to my shirt, leg bleeding, bare head, I scrambled into the saddle and rode towards the road " It is little wonder that Thackeray, one of his most avid readers, observed wryly "What can any novelist write so interesting as our own correspondent "

Yet as exciting as these accounts are, they are insufficient to provide an understanding of Russell and the world in which he operated Rarely does Hankinson probe below the surface to tackle larger questions What impelled Russell to his legendary feats of journalism, as he churned out dispatches of awesome size, most of them informed by a fine balance of detail and historical perspective? Was he driven by pride in an evolving profession, as the amateurism of legal and university training for journalists gave way to a steelier view of what was expected from a reporter? Was it the example of such prodigiously talented workmen as Thackeray and Dickens that motivated him? (Russell published his obligatory novel, *The Adventures of Dr Brady*, but it failed to make an impact) Or, to draw upon Ralph Waldo Emerson's insight, was he born with that "manly, clever" English talent for penning readable paragraphs on a variety of subjects? Then too, how about those missing warts, made much of by contemporaries who disliked Russell and by Philip Knightley in *The First Casualty*, a superficial book about war reporting that is nonetheless percipient in some of its judgments? Russell looted along with the rest of the British army in the Crimea, hated Jews, and had an ego big enough to fill the twenty-odd pieces of luggage that he carried along with him wherever he went Were these representative Victorian traits of the kind that, according to Hankinson, Russell benignly embodied?

More serious is the author's failure to shed much light on the changing nature of journalism Russell was an heroic journalist in a "golden age" of transition before the telegraph and

the camera came to be exploited for commercial ends and while middle-class readers doted on individual exploits He possessed the freedom of "the field," with little interference from those two kingmakers at Printing House Square John T Delane, the editor of *The Times*, and Mowbray Morris, its aggressive manager He profited both from the absence of military censorship and from a technology of warfare that allowed journalists considerable scope for interpretation But his run at the top was a short one By the time of the Franco-Prussian War in 1870, speed had become the *sine qua non* of effective reporting "Your letters continue to linger from seven to ten days on the road," protested Morris, as Archibald Forbes of the *Daily News* and a bevy of younger correspondents began to beat *The Times* reporter handily in the competition for news The days of the "old world sort of correspondent" were ending New skills were beginning to transform journalism, and those reporters willing to sacrifice the power of reflection for the sake of a good story were coming to be valued Hankinson understands this and refers to it in what is, in the final analysis, an absorbing book It is too bad that he does not possess a little more zest for dimensional analysis, of the kind that Russell exhibited on so many occasions on those far-off Victorian battlefields

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The Cover of the Mask: The Autobiographers in Charlotte Bronte's Fiction by Annette Tromly, pp 106 Victoria, British Columbia English Literary Studies, 1982, $5 00
Emily Bronte by Richard Benvenuto, pp 148 Boston Twayne Publishers, 1982, $11 95
Anne Bronte. A New Critical Assessment by P J M Scott, pp 144 Totowa, New Jersey Barnes and Noble Press, 1983, $27 50

BOTH ANNETTE TROMLY'S AND RICHARD BENVENUTO'S books open by describing Patrick Bronte's experiment with the mask Curious as to how each of his children would react when allowed the freedom of speaking boldly and with impunity, the Reverend Mr Bronte encouraged his youngsters to don a mask and answer his probing questions quite as they liked This incident has often been cited as the reason behind the Brontes' assumption of the pseudonym of Bell the three Bronte sisters felt safe and outspoken when they were "under the cover of the mask" Annette Tromly makes these words of Mr Bronte the title of her book and the focus of her monograph about Charlotte Hers is a detailed study of Bronte's first-person narratives, *The Professor*, *Jane Eyre*, and *Villette* Tromly believes that we have misread Charlotte Bronte, that we have spent too long looking for traces of autobiography in her fiction I doubt that any serious Bronte scholar since the late 1960s would quibble with this assertion, and if this were Tromly's only contention, we could shelve her book, unread, with a clear conscience But Tromly goes on to present a very provocative reading of Charlotte Bronte, the ironist, an artist deeply concerned with the motives and practices of self-presentation in the novel For Tromly, all three of Bronte's first-person narrators offer stories of ostensible moral progress which simplify or embellish their personal histories and ultimately yield distorted self-portraits At the center of all this, Tromly finds Bronte's own interpretation of the truth and morality of art Bronte wanted honesty about character, not eulogy or exemplified perfection She therefore remains for Tromly a moralist of the highest order, a woman who used fictional autobiographies to penetrate the human mask common alike to the self-righteous and the self-effacing

Tromly's chapter on *The Professor* is particularly fine, one of the very best readings of this book Here we are first reminded of Bronte's insistence that this book be published, despite its long history of rejections, and then asked to look closely at William Crimsworth's utter unreliability This narrator is imposing a personal mythology on life, says Tromly He encloses all the characters he describes in verbal picture frames, thus distancing them from himself and assuming power over them An innocent in a post-lapsarian world, he refuses to accept his own limitations and instead retreats to self-delusion and a semblance of control over others Thus his success story is ironic, based upon the discrepancy between personal illusion and moral growth Tromly argues persuasively that Crimsworth is not intended to grow and that Bronte wants us to see just why not

Things are different with Jane Eyre The mature Jane Rochester shows us Jane Eyre as a "potential convert" (Tromly, p 51) to the attitudes of her other characters Young Jane appears to pick and choose from among these attitudes and to become her own person along the way Tromly, however, believes that she is never ultimately secure Her Jane throws such

an aura of romanticism over her life that she too remains deluded to the very end, although her delusion is nothing of the order of Crimsworth's With this reading I would take exception One could hardly disagree with Tromly's emphasis on the subtitle of the book — *An Autobiography* —but this does not mean that Bronte intended much ironic distance from Jane The book is certainly not Bronte's autobiography, but it is a *Bildungsroman* with a romantic but chastened and creditable narrator To my mind, Tromly does better with Lucy Snowe, her idea of an autobiographer as theatrical director Tromly's Lucy, the looker-on, creates in her narrative a drama which she can watch as she writes Like Crimsworth, she gains a sense of control over life through art All the characters in her story except Paul Emanuel are subject to the sense of superiority that Lucy gains through this means Paul escapes because his death promotes Lucy's autobiography As a mediator between life and Lucy, Paul had enabled Lucy to "play" in the theater of life Her art, says Tromly, allows her a similar opportunity

Tromly's thesis clearly works best with her less lovable narrators, but her monograph is engrossing throughout She is to be commended for not backtracking to the juvenilia, or belaboring the voice of the letters, or invading Shirley Keeldar's charming and ultimately pathetic mask simply in order to write a full-blown, book-length study She says what she says well, and then concludes Bronte's autobiographers are her only subject

Benvenuto is brief, too, but for other reasons He attempts the Procrustean task of explaining to the general reader the essentials of Emily Bronte's elusive art in one short Twayne volume In general his book is marked by refreshing honesty and modesty, which brings me back to the mask Benvenuto feels that of the three Bronte sisters, Emily was the only one never wholly to remove her mask. This makes her a "mystery" to readers, "one that continues to attract the solutions it eludes" (p. 2) Going on to discuss Bronte's life and her Gondal world, Benvenuto can then rightly emphasize our lack of complete information about them both His descriptions of each are perfunctory but adequate and in line with what we know of this reclusive writer and her enigmatic saga

In his remaining chapters, Benvenuto turns to more tangible material, directing himself toward the poetry, the French essays, and *Wuthering Heights* His chapter on Bronte's poetry, carefully divided into titled subsections, again emphasizes Bronte's masks, a sound enough way of dealing with the contraries that this writer nearly always presents On Bronte's poetic themes, too, Benvenuto is solid death and life, imprisonment, nature, the imagination, mysticism Having just dealt with Gondal, he does, however, have some doubling back to do in this chapter on poetry, and his introduction and conclusion may also present some problems to uninitiated readers of Emily Bronte He opens with too compact a summary of what he intends to do and may overwhelm the student reader, while he closes with a dangerous conjecture as to why Bronte may have written virtually no poetry during the last two years of her life "It is," he contends, "possible that it was no longer necessary for her to write, because she had come to the end of her quest" (p 73) It would, I believe, have been safer simply to add her period of silence to the list of mysteries surrounding Emily Bronte

Inclusion of the French essays in Benvenuto s study is excellent We hear far too little about these fierce and provocative *devoirs*, though Benvenuto may again slightly mislead by terming them "cynical" (p 80) and could have said a word or two about their structure and style Nonetheless, they do lead neatly into his all-important chapter on *Wuthering Heights*, where forthrightness again comes to Benvenuto's aid There are, as he says, "no easy answers" (p 85) to the questions raised by *Wuthering Heights* Divided worlds, divided selves, divided narrators, divided readers — these are what mark this complicated and profound work of art, and these are what are discussed in this chapter Here once again scholars will not find much to draw them to Benvenuto, but students should find him useful

Benvenuto ends his chapters, and indeed his book, with shakier assumptions than the ones with which he begins I very much doubt that it is the living impression of Cathy and Hareton which makes the obtuse Lockwood unable to imagine "unquiet slumbers' for Catherine and Heathcliff, and yet Benvenuto concludes his discussion of *Wuthering Heights* with this assumption Nor is it correct to surmise that Bronte had dropped her mask in poem 123 (Hatfield), " 'Well some may hate ' " For all his honesty, Benvenuto strains to make final generalizations that will prove his subject to be a wise woman, one full of compassion and with ultimate answers to life's great puzzles Fierce,

proud, reclusive, extraordinary, and profound she may have been, but her masks, her shyness, and the veil between us and the dead make it impossible to talk knowingly about her wisdom

Clear declarative sentences typify Benvenuto's book, obtuse, aphoristic, and trying ones mark P J M Scott's From start to finish his is a difficult book to read, not because it is "new," as its subtitle suggests, but because of its idiosyncratic style Scott gives the sense that he is sitting back in his armchair and chatting, sometimes about Anne Bronte, but sometimes about Screwtape or E M Forster or Shakespeare or Henry James or James's brother, William, or H G Wells or Philip Larkin or John Donne — or nearly anybody literary Occasionally this is charming and illuminates his subject, but often it does not Scott is, on the one hand, familiar, cliché-ridden, and seemingly impromptu On the other hand, he is parenthetical and long-winded and can be pompous, full of foreign phrases, and words italicized for simple emphasis He also leans toward incomplete sentences Here is an example "Thus, *inter alia*, Anne Bronte's riposte to the declarations of Catherine Linton — the one who comes back as a child which has lost its way knocking at the window — in her sister's previous publication, on the subject of moral identities and loves" (p 121)

If his reading were really new, we could certainly forgive Scott for not writing well We need good work on Anne Bronte, the most earnest and probably the least masked of the three sisters, the one who answered her father's query about what she most wanted when she was under the mask with the words, "age and experience " But Scott does not give us more than a few scattered insights about Bronte and some competent explications of her poems He divides his book into four sections, dealing in sequence with *Agnes Grey*, the poems, *The Tenant of Wildfell Hall*, and the letters and theology Moralizing and large amounts of quotation from the texts characterize each section, though there are sound judgments in each as well For example, both with respect to Anne Bronte and to Nancy in *Agnes Grey*, Scott understands that religious melancholy has its source in the gulf between a sense of failure and high standards of desire and conduct, and he shows how Bronte herself struggled to overcome this melancholy He is also good on the blindness of Helen Huntingdon and Gilbert Markham regarding their marriage and on its implications for *The Tenant* Yet overall he falls short as a critic of Bronte's fiction, probably because, as he himself admits, he is such a ' thoroughgoing Jamesian in [his] aesthetics of the Novel ' (p 114) He has some turn-of-the-century standard of Jamesian perfection in mind, and when he comes to a mid-Victorian behemoth like *The Tenant*, he finds not his own critical stance wanting, but his author "out of control " Deeper probing into mid-Victorian aesthetics, society, and audience might have aided him greatly in giving us a truly fresh reading of Anne Bronte as Victorian novelist We might then have placed that reading alongside his more insightful assessment of her as a poet "capable of things quietly extraordinary" (p 71) and found a third Bronte sister whose dual talents we could begin to reveal, if not to unmask

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Robert Louis Stevenson, edited by Andrew Noble, pp 232 London Vision Press, 1983, Totowa, New Jersey Barnes and Noble, 1983, $27 50

The Definitive "Dr. Jekyll and Mr Hyde" Companion, by Harry M Geduld, pp x + 219 London and New York Garland Publishing, 1983, $25 00

A Newly Discovered Long Story "An Old Song" and a Previously Unpublished Short Story "Edifying Letters of the Rutherford Family" by Robert Louis Stevenson, edited by Roger G Swearingen, pp 102 Paisley, Scotland Wilfion, 1982, Hamden, Connecticut Archon, 1982

ANDREW NOBLE'S INTRODUCTION TO THIS COLLECTION of critical essays cautions us about the vicissitudes of Robert Louis Stevenson's literary reputation and the dangers inherent in deep-reading his potboilers Noble rejects any attempt to radically revalue Stevenson's reputation, claiming instead that the essays intend to suggest "Stevenson's ambivalent relationship to his audience and to money" (p 21) While this is certainly an important feature of them (Stevenson's letters throughout present his struggles between making art and making a living), Noble is describing what emerges as a secondary theme in the essays The dominant theme could be called Stevenson's ambivalence toward genre, his continual testing of the limits of romance, allegory, adventure tale, and realism

In fact, the essays among themselves carry on

the discussion between David Daiches and Leslie Fiedler on whether to assign realism or romance the higher place in Stevenson's work One group of essayists attend to Stevenson's realistic aspects Kenneth Graham's "Stevenson and Henry James A Crossing" defines James's influence in turning Stevenson against the strictures of fairy-tale and allegory James Wilson's essay on Stevenson's travel writing shows the occasional foregrounding of the "nondescript and the shoddy" (p 77) in *An Inland Voyage* (1878) and *Travels with a Donkey* (1879) and moves thence to the more squalid side of life in *The Amateur Emigrant* (1880) Kenneth G. Simpson analyses how the narrative technique in *Weir of Hermiston* reflects the theme of the limitation of human judgment, revealing Stevenson to be moving beyond the romance to the "novel with a purpose' (p 205)

The second group of essayists examine Stevenson's romance writing Honor Mulholland and Peter Gilmour separately discuss the compromisings of the romance form and adventure tale, while Carol Mills outlines the disunity in *The Master of Ballantrae* as a result of Stevenson's experimentations with genre Noble's essay on Sir Walter Scott's and Stevenson's historical romances describes the form's shortcomings in the hands of both authors In general, this second group of essayists emphasizes Stevenson's failures — Stevenson avoided the problems of Highland history, Scottish self-awareness, and British imperialism — and his failures arise in no small part from his choice of the romance as the form in which to take on those problems But I wonder, along the lines of Simpson's analysis, whether Stevenson did not in some cases use the romance form only as his starting point *The Master of Ballantrae*, *Catriona*, *The Ebb-Tide*, "The Beach of Falesá," and *Weir of Hermiston* continually surprise us with their ability to be seen in terms of different genres The question then is to what degree they borrow from the realistic novel, the historical romance, the fable, and the epic tragedy The very breadth of genres discussed in these critical essays suggests more than a craftsman who cannot satisfy both art and Mammon, the breadth suggests a deft artist, whose literary reputation as principally a romance writer could stand some revaluation

The Definitive "Dr Jekyll and Mr Hyde" Companion regards the story as both literary creation and pop icon Besides the analogues by Edgar Allan Poe and Thomas Berger, and critical essays ranging from Malcolm Elwin's biographical backgrounding to Mark Kanzer's psychoanalytical deep-reading, Harry Geduld has also included "Jeux d esprit" (parodies of the original), "Jekyll and Hyde in Theatre and Film," and appendices listing the stage, film, and recorded versions of *Dr Jekyll and Mr Hyde* One obvious slip exists in the introduction *Dr Jekyll and Mr Hyde* (1886) cannot be "anticipating the psychic conflicts of doubles" (p 3) in Dostoevsky's *The Devils*, when the latter was published in 1872

Literary scholars will find the book thin on critical matter, regretting the inclusion of criticism of narrow significance, such as the piece on the surname Jekyll, and regretting the absence of Vladimir Nabokov's Cornell University lecture describing the Jekyll-Hyde personality Geduld has also unfortunately decided to prune an excerpt from Masao Miyoshi s *The Divided Self A Perspective on the Literature of the Victorians* (1969) to the point of rendering it pointless Those who are interested in the history of the Jekyll-and-Hyde theme will find *The Definitive Companion* more to their purpose, although even here there are listed too many variants with only a tenuous connection, such as *The Blue Dahlia* (1946), Brian de Palma s *Sisters* (1973), various animated films, and mad scientist-cum-serum films The most intriguing portion of the book lies in Geduld's explanation of why the sexual-sadistic theme that arose in stage and film versions came to overshadow the original story the first stage adaptation of *Dr Jekyll and Mr Hyde* opened in London only one month before Jack the Ripper first struck in the East End in 1888 A terrified public deluged the London police with "names of suspects, and high on the list was Richard Mansfield" (p 6), the English actor who portrayed both Jekyll and Hyde As a critical companion to the original story, the book is not more than a beginner's guide, as a reference to the plethora of variants and layers of meaning the original story has accrued since 1886, *The Definitive Companion* is a valuable tool

up "An Old Song," the author's first published short story, serialized in February and March 1877 ' An Old Song" is a seriously flawed effort, with its grim little theme of delusion lashed to an aimless plot and shallow characters Swearingen points out, however, that its grimness reveals a "mode of imagining to which Stevenson had access from the beginning" (p 15) "Edifying Letters" (approximately 1876-1877) is a more satisfying piece of literature and yet another example of Stevenson's treatment of youthful rebellion against parental authority, Scottish morals, and Scottish society — themes that appear with regularity in his fiction and that flower in *Weir of Hermiston* (1894) Unfortunately, the protagonists of these two stories have more in common with the pale young loungers of *New Arabian Nights* (1882) and *The Dynamiter* (1885) than they do with the powerfully drawn Archie Weir of Stevenson's last novel Neither "An Old Song" nor "Edifying Letters" is likely to recast our perceptions of Stevenson's fiction, but both may serve to emphasize the consistency with which Stevenson relied on the themes of familial conflict and filial rebellion

RICHARD A BOYLE

Indiana University

Origins of Enterprise Business Leadership in the Industrial Revolution, by Katrina Honeyman, pp 213 Manchester Manchester University Press, New York St Martin's Press, 1982, £16 00

IN EXPLANATIONS OF ECONOMIC GROWTH DURING the period of the British industrial revolution, a role of varying importance has often been allotted to the entrepreneur Some attention has inevitably been paid to the origins of such business leadership In the middle of the nineteenth century, Samuel Smiles espoused the route to wealth through self-help, a kind of rags-to-riches scenario More recent writers such as T S Ashton have argued that, deprived of advancement in church and state and with a theology emphasizing thrift, Nonconformists provided the seedbed for enterprise Other alternatives have also been put forward to explain the emergence of a business class in Britain, such as the fluid nature of British society which facilitated, so it is said, upward mobility Katrina Honeyman's concern is to challenge the small man thesis put forward by Smiles To do so she takes evidence from three industries Derbyshire lead mining, Lancashire cotton spinning, and Nottinghamshire lacemaking These industries, she suggests, provide a suitable cross-section of size, structure, and entrepreneurial type

For each industry Honeyman takes the information available about the investors and analyzes it by occupation and social rank, using the classification that Charlotte Erickson employed in her study of British industrialists in steel and hosiery in the nineteenth century For the lead industry, Honeyman finds that investors were composed largely of previous elites Then, while it was possible for a small man to invest in the cotton spinning industry, those who invested in successful concerns were more likely to have both capital and previous experience Similarly, in the lace industry she finds that only a small proportion of the small manufacturers emerged from humble origins From the foregoing, it can clearly be seen that the intended scope of this book is much slighter than the title and subtitle — no doubt invented by the publisher to increase sales — suggest Moreover, the book may be based on a misconception What Honeyman attempts to measure is investment, what she does not discuss at all is decision-making Certainly, if eighteenth-century trade provides any kind of example, there was a clear distinction between management and finance If this distinction applied to industry as well, Honeyman's conclusion would just be that those who invested in industrial enterprises had money already, hardly a surprising one There are problems too about presentation This book has not really successfully emerged from the chrysalis of the Ph D dissertation Not every self-evident generalisation needs buttressing with annotation And, since the publisher has decided to have endnotes rather than footnotes, much of the information contained in the endnotes should have been embodied in the text Nor has the bibliography been systematically updated since the completion of the thesis in 1977 Within its limits — the three industries with which she is concerned — Honeyman has provided some useful information about the volume of investment and the nature of the investors, but she has not really tackled the question of the origins of enterprise nor provided a discussion of business leadership in the industrial revolution

WALTER MINCHINTON

University of Exeter

Peaceable Kingdom Stability and Change in Modern Britain, by Brian Harrison, pp x + 493 New York Oxford University Press, 1982, $49 50

BRIAN HARRISON'S BOOK IS AN EXAMPLE OF CONsensus history, which was once more popular in Great Britain and America than it is today It praises moderate reform that avoided extremes and reduced seemingly insoluble problems in British life Written by an admitted political centrist, the book praises men and women reformers of moderate views, and perhaps the name which appears most often is that of Halifax the Trimmer

The time covered is from late eighteenth century until today, and while politics plays an important role, there are also chapters dealing with the protection of animals, temperance agitation, and philanthropy The book is a series of essays rather than a narrative, three of the eight chapters appeared originally as articles in historical journals The chapters are nevertheless coordinated around a major theme — the triumph of centrist rather than extremist views

I believe that Harrison succeeds in explaining Britain's unusually gentle political and social evolution a process which contrasted with the development of most other countries In essence, moderate proposals for change met with moderate resistance, Britain gradually evolved into the country she is today while avoiding the extremes of revolution and reaction This view is of course in the mainstream of British historiography

Harrison's heroes are "William Wilberforce rather than Thomas Clarkson, Richard Cobden rather than John Bright, John Colam rather than Frances Power Cobbe, James Stansfeld rather than Josephine Butler, Eleanor Rathbone and Mrs Fawcett rather than Christabel and Emmeline Pankhurst" (p 25) Among politicians he prefers William Huskisson, James Graham, Lord Rosebery, Henry Campbell-Bannerman, Herbert Asquith, R A Butler, Iain Macleod, "and the founders in 1981 of the Social Democratic Party" (p 322) It seems strange to see the name of George Canning in a long list of "centrist" politicians since Canning was inclined to right-wing extremism in domestic politics Harrison does not much care for the Ultras of the 1820s, the Clydesiders, the later Enoch Powell, Margaret Thatcher, or Anthony Wedgwood Benn He obviously favors centrists who resist extremism inside their own party as well as outside it The two-party system is seen as the norm, itself a tribute to moderation

Perhaps the most valuable part of Harrison's book is his discussion of the development of respectability among British workers "Education, thrift, prudent expenditure, religious idealism, and secular crusading were all dimensions of working-class respectability" (p 177) Of course, these are often thought of as middle-class virtues, and Harrison acknowledges that as the laborer eschewed drunkenness, rowdyism, and wife beating, his home became like that of a member of the bourgeoisie In several thoughtful pages, Harrison notes that the contemporary Labour Party's permissiveness and elitist attitudes toward immigration and personal conduct have offended solid members of the working class Meanwhile, the Conservative Party with its nationalism and more relaxed attitudes toward sport and pastimes has been able to acquire and hold the allegiance of many workers On this issue, Harrison cites much relevant secondary literature and seems to imply that the Labour Party intellectuals have had a habit of demanding too much from those whom they have attempted to lead People who struggle to find a distinct working-class culture in the Britain of the last 200 years will not be pleased by what they read here

While Harrison concludes his book by citing John Stuart Mill's view that improvement in human affairs is wholly the work of the uncontented characters, his sympathies are clearly with reformers rather than radicals The former are often rather colorless and unimaginative, lacking in sparkle and brilliance, but they make the system work and things do get done Their skill at drafting and proposing legislation and ability to create a receptive mood for reform do more good than the spectacular but often surface qualities of extremists

It is not surprising that there is praise in this book for Thomas Babington Macaulay and G M Trevelyan Harrison is himself in many ways a Whig historian Like Trevelyan he looks over modern British history and finds it to be on the whole good Less passionate and more analytical than the great Whig historians, Harrison is, nevertheless, proud to record that generally peaceful accommodation to change which is such an astonishing feature of British life during the last few centuries Few countries can duplicate this, and none of them is a country that is as complex as Britain Harrison asserts that this fact will contribute to the survival of British history as a study, despite Britain's

decline in international status Perhaps In the United States, where university education is more and more a burlesque, interest in British history has been declining for years I doubt whether the typical undergraduate in America or in most other parts of the world will either know or care about what Harrison has to say This is an interesting and appealing book, and it is appropriate that it was written by a don at Oxford, that home of lost causes

JOHN W OSBORNE

Rutgers University

Charles Blacker Vignoles Romantic Engineer, by K H Vignoles, pp xii + 187 New York and London Cambridge University Press, 1982, $44 50

BRITISH ENGINEERING BIOGRAPHY HAS BEEN A VERY selective business The popular subjects were all dead by 1860, and it has been to the pre-1860 period, the great age of canal and railway construction, that subsequent generations of biographers have tended to return Even within this pre-1860 period, there has been a charmed circle of acknowledged heroes — Thomas Telford, James Watt, Richard Trevithick, John Rennie, the Brunels, and the Stephensons — who have virtually monopolised the attention of historians studying the rise of engineering in Britain However understandable such a selective treatment may be, there can be no doubt that it has been unfair to some very considerable figures, among whom the subject of the study under review, Charles Blacker Vignoles, is an outstanding example

Born in 1793, Vignoles was orphaned in infancy and was brought up by his maternal grandfather, the mathematician Dr Charles Hutton He went into the army, seeing active service at the end of the Napoleonic Wars, and he retained his commission and found it convenient on occasion, as when trying to impress potential clients such as Tsar Nicholas I, to don his military uniform He undertook surveying and map-making in South Carolina and Florida before being caught up in British civil engineering works This occurred in the 1820s, when the first tentative railways were being established, Vignoles was responsible for surveying the route on which George Stephenson then built the Liverpool and Manchester Railway He went on to engineer a clutch of railways in the northwest and the midlands of Britain, including the Sheffield and Manchester Railway, for which he determined the alignment and designed the Woodhead Tunnel before he quarreled disastrously with the directors and left the line for Joseph Locke to complete He built railways in Ireland, especially the Dublin and Kingstown with its atmospheric extension to Dalkey which persuaded I K Brunel to apply the principle on his South Devon Railway Vignoles' career interwove to a quite extraordinary degree with those of the railway triumvirate of Brunel, Robert Stephenson, and Locke, and he outlived all of them by a quarter of a century

Why then did Vignoles not receive comparable acclaim? One reason, suggested by the author of this book in adopting the subtitle "Romantic Engineer," is that Vignoles did not have the single-minded vision of his famous contemporaries He certainly worked fantastically hard and obsessively when he undertook tasks, but the range of his commitments tended to be wide and varied His facility with foreign languages made him a welcome recipient of invitations to undertake work overseas, and it was in this field that his greatest engineering achievements, such as the Kiev suspension bridge over the Dnieper in Russia and the Tudela and Bilbao Railway in northern Spain, were accomplished Even at home his activities, although remarkable, were somewhat mixed, as when he took the Chair of Engineering at University College London for a short time in 1841, and this possibly contributed to the lack of precision in his public image that hindered the spread of his reputation He tended to accept any work which came his way because he was permanently short of money, which in turn could be attributed partly to his flamboyant lifestyle as well as to his generosity and imprudent investments For above everything, as his biographer observes, "He was himself a gentleman in every sense of the word" (p 171)

Vignoles has, at last, found a worthy biographer His son, a clergyman, the Rev Olinthus Vignoles, produced a dutiful work of filial piety in 1889, but his great-grandson has done much better with the present study The author has had access to some valuable family documents, as well as to Vignoles' diaries, which are in the British Library, and as a result he has produced this well-written and instructively illustrated book of modest length The material has been judiciously selected and presented in order to give a well-balanced account of all the aspects of Vignoles' life His Huguenot and Irish ancestry

is sketched in, his strong-headed and rather hot-tempered character is described, his various commitments and undertakings are outlined in succession, and his difficult family life, as his good-natured but temperamentally cautious wife became increasingly care-worn and nervously exhausted, is fitted into the framework of his career The format of the book is somewhat unusual for Cambridge University Press, which does not normally give such attention to illustrative material, but the new departure does not detract from the scholarly value of the book and should be welcomed, although a minor irritation is the failure to inset long quotations in a smaller type-face than the main text

A particularly happy note about this book is the fact that it is dedicated to the memory of Sir Arthur Elton Elton was a devoted collector of Victorian iconography, who knew of Vignoles' work through the splendid illustrations of the Kiev Bridge drawn by John Cooke Bourne, which led him to encourge the author to write this book As a result, we now possess a very readable and manageable study which places C B Vignoles where he belongs amongst the giants of British engineering history

R A Buchanan

University of Bath

Conflict and Compromise Class Formation in English Society 1830-1914, by Dennis Smith, pp xiii + 338 London and Boston Routledge and Kegan Paul, 1982, $39 95

DENNIS SMITH CLAIMS TO DO A LOT IN HIS BOOK He achieves much less The alliterative but opaque phrase which forms the title is qualified by a subtitle which proves to be a quite inaccurate summary of the text On the book's title page, another subtitle joins the queue — "A Comparative Study of Birmingham and Sheffield" — which gives a truer, albeit vague, description of the contents

In effect, chapters two to ten of this book consist of a conventional history of aspects of the development of two English provincial cities from around 1830 to the 1890s — despite the first subtitle, the years just before the Great War get little attention The first of these chapters sets out some differences between the social structures and social contexts of the two cities, concentrating on their particular relationships with the land-owning, aristocratic, "old order" in which they were embedded and which they challenged Then, though other aspects and institutions are alluded to, the book focuses on educational policies and provision in Birmingham and Sheffield and the forces which accounted for variations and similarities This is what the book is mainly about and it is a pity this is not made clear in the titles nor in Smith's attempts to present his empirical material to the reader I have said that this part of the book consists of conventional history, by which I mean that the author sets out to provide a wealth of detail about the chosen cities (not all of which is relevant to the topics supposedly under consideration), that a narrative account is provided with little attention paid to theoretical or methodological matters, and that there is a concentration on individuals and individual thinkers as the heroes of the account

Now, this descriptive section of the book is wedged between a preface, first chapter, and a last chapter, in which Smith makes even more claims for his text — "an important sub-theme on the development of the professions runs through the book" (p xii) — and in which he tries to provide an analytical framework both to indicate the significance of his empirical chapters and to validate the pretensions of his title and subtitle These chapters are woefully weak To begin with, they are written in a kind of wordy sociologese — phrases like "social formation," "contradictory tendencies," "structural differentiation," and so on abound — which might sound "theoretical" but never actually explains or elucidates what is under discussion Secondly, Smith does not use these chapters to discuss various theoretical ideas about class, class formation, and class conflict supplied by other authors One can read, and reread, Smith's work without ever knowing that anyone else had ever argued about or tried to explain such matters, let alone finding a resumé of what they said It seems an odd way of proceeding to label your book as about class formation and conflict but provide no discussion or evaluation of the theoretical notions about such matters contained in a good deal of sociology and social history Smith's guiding theme is that the class structures and institutions of an agrarian society interrelated with those of the rising urban and industrial social order Smith warns how complex a process this was, tells how it varied between the two cities, picks out various levels of integration, makes distinctions and so on, but, at the end, this theme remains at the level of description only and is hardly startl-

ing as an organising idea to anyone who has thought at all deeply about Victorian society

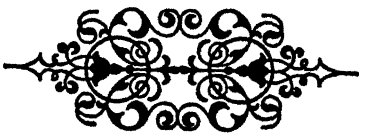
Thirdly, ignoring the extant literature relevant to his purported project also allows the author to operate with an undisclosed and imprecise model of class and more general social stratification Smith does not reveal what his own theoretical basis of class formation is (and so division and so conflict and compromise) and uses just about every concept in the stratification lexicon in his "theoretical" section "Establishments" rub shoulders with "the wealthy," "old professions" with "the division of labour," "bureaucracy" with "the middle class," "artisans" with "elites," and so on What comes out of this theoretical promiscuity is that class, status, and power groups are used by Smith as more or less interchangeable concepts On his penultimate page, Smith claims his analysis has gone "beyond a quasi-Weberian survey of the strategies of competing status groups engaging in contingent encounters " Whatever one may think of this as a summary of a Weberian account of *class* divisions, it is remarkable in being the first and, apart from a throwaway sentence on the last page dismissing Marxist approaches, the only guide to class theory and Smith's position in the whole book This absence of a theoretical argument means it is never made clear why there is such a concentration on education (as opposed to work or politics, for example) in a book supposedly about class structures, conflict, and compromise

In sum, if you are interested in Victorian education, this book may be of some value to you, if you are interested in Birmingham or Sheffield, the book may provide material for you If you are interested in social stratification, in class alignments, conflicts and accommodation, in deference, sectionalism, incorporation, and compulsion, this book has little to offer Smith fails to tell the reader much about class formation or class relations in nineteenth-century Britain, and it is difficult for me to understand why he suggests that his book does this

H F Moorhouse

University of Glasgow

COMMENTS AND QUERIES



CHANGES AT *VS*

Allyn Roberts is our new Managing Editor, replacing Allyson McGill, who returns after a summer at Oxford to teaching and dissertation work at IU Allyn is writing her thesis on the Victorians' distortions of classical Greece Catherine Hoyser, Ph D candidate, joins our staff as Editorial Assistant Catherine's topic of research is the female *Bildungsroman* of a number of late Victorian writers Eric Montenyohl, a doctoral candidate in Folklore at IU, replaces Moureen Coulter as Book Review Editor for Volume 28 Eric's research is on Victorian folk and literary tales, with particular attention to Andrew Lang After five years, we send our best wishes to Joonok Huh, former *VS* Business Manager, who has accepted an assistant professorship in American literature at Illinois State University at Normal Our new Business Manager, Joelene Bergonzi, has been educated in accounting, psychotherapy, theatre, and motherhood — all skills that she uses in her current position

THE BERKSHIRE CONFERENCE OF WOMEN HISTORIANS will award its annual prizes for the best book and the best article in any field of history written by an American woman and published during 1984 Submissions for the book award should be sent to Anne Russ, Wells College, Aurora, NY 13026, and for the article award to Margaret Darrow, Department of History, Dartmouth College, Hanover, NH 03755 Two copies of the book or article are required Deadline for submission is 1 February 1985

A CONFERENCE ENTITLED "A CENTURY OF WOMEN'S HEALTH — PRACTICES AND PRACTITIONERS," will be held at the University of Arizona, Tucson, 15-16 February 1985 For further information, contact Lolly Dwan, Continuing Medical Education, University of Arizona College of Medicine, Tucson, AZ 85724

VICTORIANS AT HOME will be the topic of the Ninth Annual Meeting of the Midwest Victorian Studies Association in Chicago, 26-27 April 1985 For information, write Kristine Ottesen Garrigan, Department of English and Communication, DePaul University, 2323 North Seminary Avenue, Chicago, IL 60614

CINEMATIC AFFINITIES DICKENS, FICTION AND FILM is a conference slated for early August 1985 at the University of California, Santa Cruz All inquiries regarding the conference should be sent to Barbara Gottfried, The Dickens Project, Kresge College, University of California, Santa Cruz, CA 95064

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DAVID K VAN KEUREN, an Andrew W Mellon Foundation fellow at the American Philosophical Society, is currently compiling a research bibliography on manuscript sources for the history of anthropology in the library of the American Philosophical Society He is continuing his research on the institutional history of Victorian social and natural science

RICHARD A BOYLE, a recent Ph D of the English Department at Indiana University, has done his dissertation on Robert Louis Stevenson and realism, which examines the elements of realism in Stevenson's later fiction, 1888 to 1894

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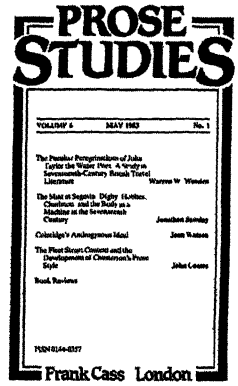
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for 1985-86

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DUTIES: In addition to taking part in the discussion of manuscripts the Editoral Assistant helps the editors keep abreast of developments in the Victorian field and assists with correspondence, proofreading, copy-editing, and layout work The assistantship (an eleven-month, half-time position) begins on 1 August

QUALIFICATIONS. The assistant must enroll, through a department, in the Graduate School of Indiana University. A familiarity with the Victorian period and teaching or editorial experience are preferred, though not required.

APPLICATIONS: First, and most important, candidates should write us a letter outlining their academic experience and indicating the relevance of Victorian Studies and the assistantship to their graduate work and future plans. We will send them application forms, which should be returned with a full academic transcript. Since such forms allow small scope for personal expression, the candidate's initial letter will weigh heavily in the process of selection. Applicants from all countries are welcome.

Ordinarily, in the second year, the Editorial Assistant succeeds to the position of Managing Editor (also a half-time position), for which the current stipend is $6,150. Applicants should therefore expect to be in residence through 1986-87.

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The closing date for all applications and supporting materials is 1 February 1985 Americans presently studying in another country and foreign candidates should note that a personal interview has been an important factor in the choice of the assistant Candidates should write to the Editor, VICTORIAN STUDIES, *Ballantine Hall 338, Indiana University, Bloomington, Indiana 47405*